GOVERNMENT OF MALAYSIA

THE FEASIBILITY STUDY OF COMPUTERISED AREA TRAFFIC CONTROL SYSTEM IN PENANG, MALAYSIA

FINAL REPORT

SUPPLEMENTARY VOLUME

JANUARY 1988

JAPAN INTERNATIONAL COOPERATION AGENCY

THE FEASIBILITY STUDY OF COMPUTERISED AREA TRAFFIC CONTROL SYSTEM IN PENANG, MALAYSIA
FINAL REPORT
SUPPLEMENTARY VOLUME
JANUARY 1988

GOVERNMENT OF MALAYSIA

THE FEASIBILITY STUDY OF COMPUTERISED AREA TRAFFIC CONTROL SYSTEM IN PENANG, MALAYSIA

FINAL REPORT

SUPPLEMENTARY VOLUME

JANUARY 1988

JAPAN INTERNATIONAL COOPERATION AGENCY

This **Supplementary Volume** on the Feasibility Study of Computerised Area Traffic Control System in Penang, Malaysia presents the work done from late July 1986 to late September 1987.

This **Supplementary Volume** comprises of **Section A** and **Section B.**

There are five chapters in **Section A.** These are briefly outlined below:

Chapter 1 introduces the Study background, objectives, and approach.

Chapter 2 discusses the existing transport system and problem in the Study Area based on the data obtained mainly from the various traffic surveys conducted.

Chapter 3 presents the traffic demand projection and future traffic situation under the existing transportation system.

Chapter 4 describes the formulation of each desirable Transportation System Management Plan.

Chapter 5 presents the final consolidated Transportation System Management Plan.

There are four parts in **Section B.** These are briefly outlined below:

Part I presents the Area Traffic Control System Expansion Plan. This involves the elaboration of the expansion plan for the Computerised Area Traffic Control System and its associated works as well as its appraisal and economic evaluation.

Part II discusses in detail the Pedestrian Path Network Plan in the Central Area of George Town inclusive of its implementation programmes.

Part III describes the CBD Bus Terminal Plan which includes the examination and evaluation of terminal functions and its location.

Part IV presents the improvement plans for Perak Road, Dato Keramat Road as well as the intersection of Perak Road and Dato Keramat Road.

TABLE OF CONTENTS

SUPPLEMENTARY VOLUME

SECTION A

SUPPLEMENTARY VOLUME

SECTION B

LIST OF FIGURES

SUPPLEMENTARY VOLUME

SECTION A

SUPPLEMENTARY VOLUME

SECTION B

PART I : AREA TRAFFIC CONTROL (ATC) SYSTEM EXPANSION PLAN

PART II : PEDESTRIAN PATH NETWORK PLAN IN CENTRAL AREA

PART III : CBD BUS TERMINAL PLAN

PART IV : ROAD AND INTERSECTION IMPROVEMENT PLAN

LIST OF TABLES

SUPPLEMENTARY VOLUME

SECTION A

SUPPLEMENTARY VOLUME

SECTION B

PART I : AREA TRAFFIC CONTROL (ATC) SYSTEM EXPANSION PLAN

PART II : PEDESTRIAN PATH NETWORK PLAN IN CENTRAL AREA

PART III : CBD BUS TERMINAL PLAN

Section A

1.0 INTRODUCTION

1.1 Background

In response to the request of the Government of Malaysia, the Government of Japan has decided to conduct a Feasibility Study for the Expansion of the Computerised Area Traffic Control System for the Greater George Town, Central District Development 21 and Bayan Baru District in Penang, Malaysia (hereinafter referred to as "The Study"), and in accordance with relevant laws and regulations enforced in Japan. The Japan International Cooperation Agency (hereinafter referred to as "JICA"), the official agency responsible for the implementation of technical cooperation programmes of the Government of Japan will undertake the Study in close cooperation with the relevant Malaysian authorities.

With a population of 260,000, George Town is the third largest city in Malaysia and an important centre for commerce and tourism. To overcome urban transport problems such as the traffic congestion that George Town has been facing, a request was conveyed to the Japanese Government to carry out a comprehensive study for preparing the George Town Metropolitan Area Transport Masterplan. Such a study was conducted by the Japan International Cooperation Agency (JICA) in March 1979 and an Urban Transport Masterplan was prepared in 1980. The Masterplan has recommended a series of proposals among which were construction of the Penang Outer Ring Road as the Long Term Road Network Improvement Measure as well as short term or interim measures such as reorganization of bus network, parking regulation and control, intersection improvement and the implementation of an Area Traffic Control (ATC) System.

Consequently, with the acceptance of these proposals by the Malaysian Government, a Feasibility Study for the Outer Ring Road was conducted in 1981–1982 by JICA. In addition, technical experts have been dispatched to Penang for further technical cooperation and the undertaking of traffic management system planning.

With the completion of the Penang Bridge and the comprehensive Central Area Redevelopment Project (Komtar Project) in 1985, the volume of urban traffic has increased manyfold, further aggravating urban transport problems in Penang. The Penang Municipality therefore decided to implement the first stage of the Area Traffic Control (ATC) System with the help of the Government of Japan who contributed various necessary equipment such as the central microcomputer control and information display board in 1985.

Based on the above background of urban transport planning in Penang, this Study has structured a comprehensive urban transportation system management plan examining in particular the feasibility of expanding the ATC System of Penang.

1.2 Objective

The objectives of this Study are:

(1) To conduct traffic surveys and to formulate a comprehensive traffic management plan in the Study Area, including a pedestrian path network plan.

(2) To formulate a future computerised Area Traffic Control (ATC) System for the Study Area.

(3) To conduct the feasibility study of the proposed system.

(4) To propose the most appropriate implementation programme for the future ATC System in the Study Area.

The Study Area covers the eastern part of Penang Island (Greater George Town, Central District Development 21 (C.D.D. 21) and Bayan Baru district) as shown in Figure 1.2.1.

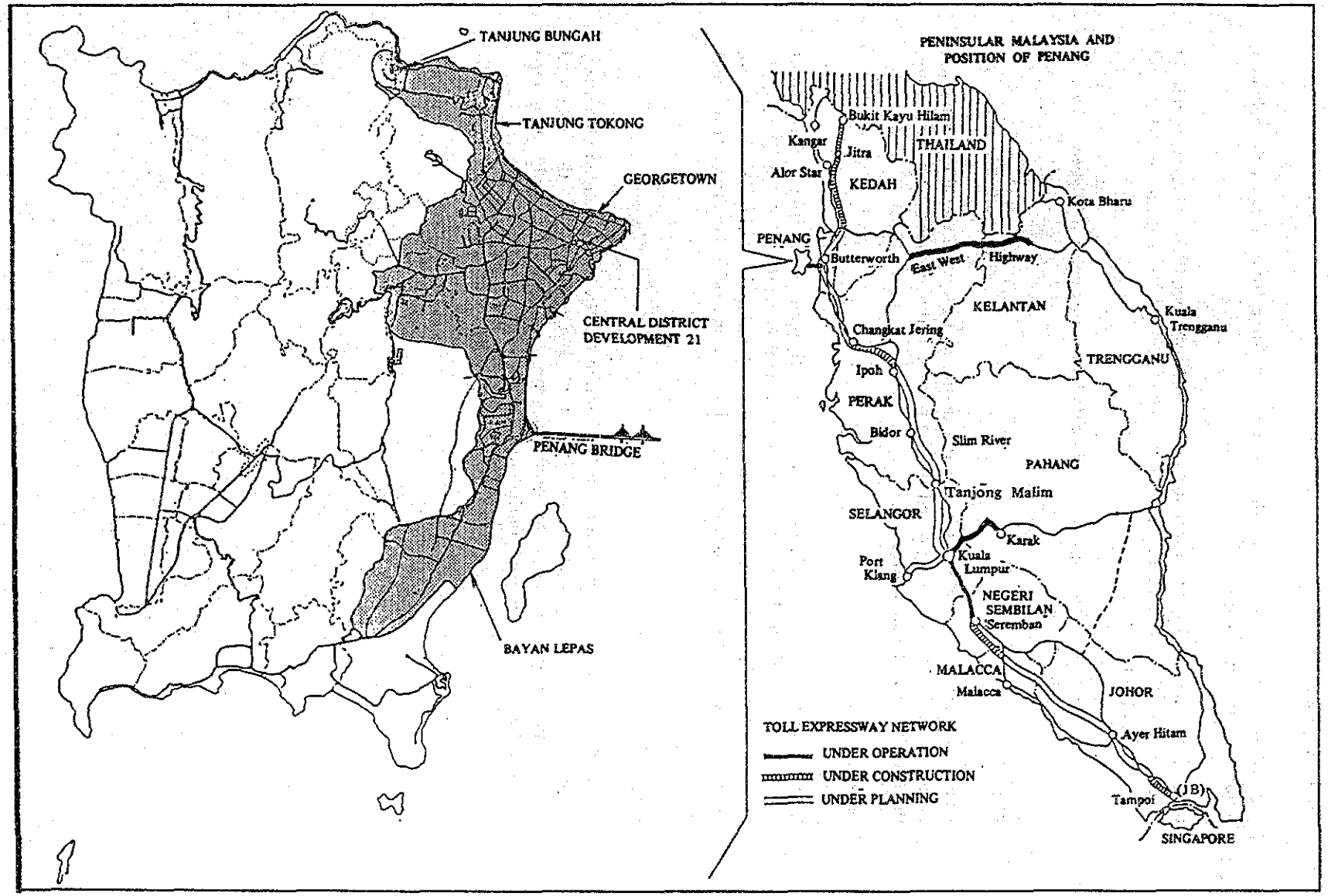


Figure 1.2.1 : Study Area

1.3 Study Approach

This Study was carried out in three (3) Phases for a total of ten (10) calendar months in Penang, Malaysia.

Phase I commenced in July 1986 and ended in November 1986. Phase II was from November 1986 and ended in March 1987 while Phase III was from July 1987 and ended in September 1987.

The main works in each phase are highlighted in a flowchart in Figure 1.3.1 and further elaborated below:

Phase I :

Phase I undertakes the identification of existing as well as foreseeable traffic and transport problems in Penang based on the results of the various traffic surveys and the future traffic-demand forecasts.

Phase II :

Phase II involves the formulation of improvement plans for traffic and transport facilities essential for Transportation System Management (TSM). This includes in particular the improvement and expansion plan for the ATC System, improvement plan for the Pedestrian Path Network and other facility improvement plans.

Phase III :

Phase III proposes an Implementation Programme for the recommended plan duely evaluated using the economic and financial analysis. From the proposed implementation programme, a set of priority projects will be selected, taking into account their potential impact on the city's development.

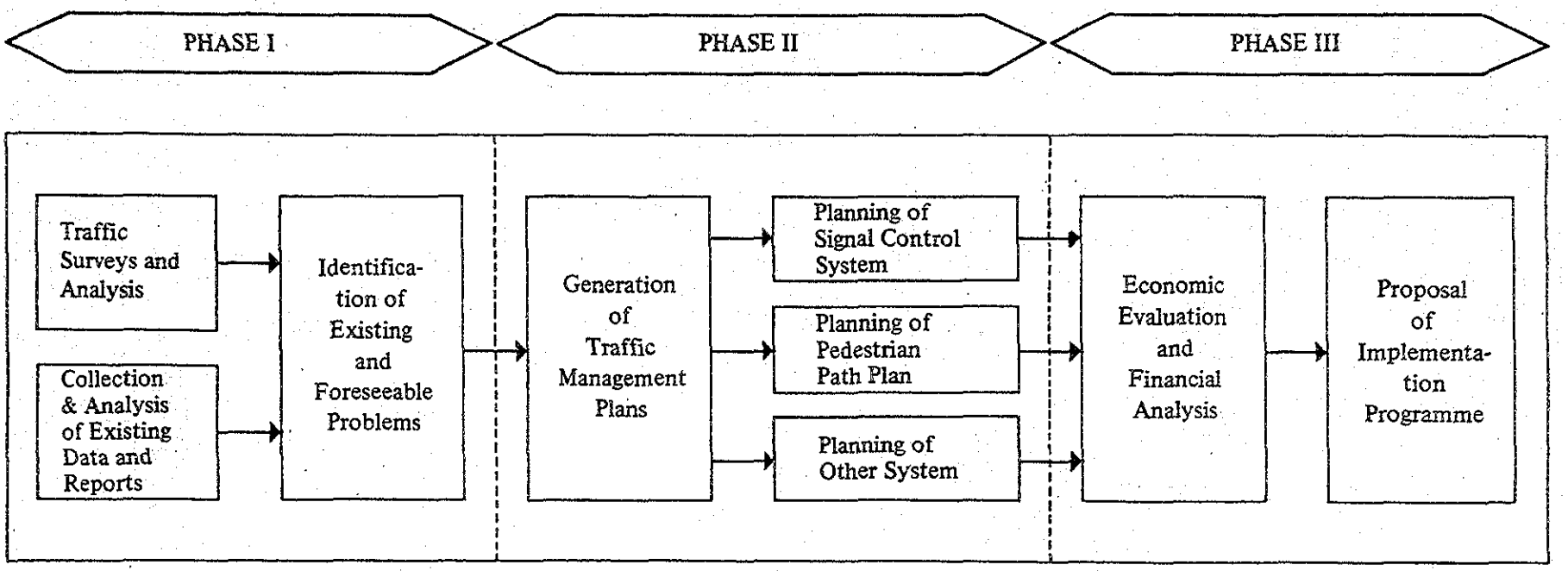


Figure 1.3.1 : Phasing of the Study

2.0 EXISTING TRANSPORT SYSTEM AND PROBLEM

2.1 Traffic Survey

2.1.1 Traffic Survey Conducted

Traffic surveys were conducted to collect basic data for analysis in the course of preparing Transportation System Management (TSM) Plan, Area Traffic Control (ATC) System, Pedestrian Path Network Plan and other related measures.

The surveys conducted could be classified into six (6) types, they were :

(1) Vehicle Origin and Destination Survey
- Vehicle Owner Interview Survey
- Cordon Line Interview Survey
- Screen Line Traffic Count Survey
- Vehicle Passenger Occupancy Survey

(2) Traffic Count Survey
- 12-Hour Traffic Count Survey at Intersection
- Traffic Count Survey for Volume Conversion

(3) Travel Time Survey

(4) Public Transport Survey
- Stage Bus Survey
- Factory Bus Survey
- School Bus Survey
- Taxi Survey

(5) Parking Survey
- Parking Supply Survey
- Parking Duration Survey
- Parking Interview Survey
- Land Use Survey

(6) Pedestrian Survey

The details of each survey are illustrated in Table 2.1.1.

The survey methodology of the Vehicle Origin and Destination Survey was similar to that of the same survey conducted in the Urban Transport Study in Greater Metropolitan Areas of George Town, Butterworth and Bukit Mertajam in 1979 in order to grasp the changes in traffic conditions.

Table 2.1.1(1) : Traffic Surveys Conducted

Survey No	Survey Type	Purpose	Survey Period	Actual Sample Size	Actual Sample Rate
VEHICLE ORIGIN and DESTINATION SURVEY					
1	Vehicle Owner Interview Survey	To obtain existing detailed travel pattern conditions especially of the origin and destination of each trip made.	August 11 to October 10	9,609 all vehicles except motorcycle 8,267 motorcycles	9% 6%
2	Cordon Line Interview Survey	To collect cross-section traffic data in the Study Area and external to internal traffic volume.	September 15 to September 18	6 survey locations 1,700–4,100 vehicles	12%–52%
3	Screen Line Traffic Count Survey	To obtain existing traffic volume on the Screen Line and to verify the results of the Vehicle Owner Interview Survey.	August 12 to August 14	8 survey locations	Not Applicable
4	Vehicle Passenger Occupany Survey	to determine the number of vehicles and people moving in and out of the Central Area, the composition of the different transportation modes and the occupancy rate of each transportation mode.	September 30 to October 2	7 survey locations	Not Applicable
TRAFFIC COUNT SURVEY					
5	12-Hour Traffic Count Survey at Intersection	To model the characteristics of turning movement at intersections and to obtain the hourly fluctuation of traffic volume.	August 19 to October 6	46 survey locations	Not Applicable
6	Traffic Count Survey for Volume Conversion	To convert 12-hour traffic volume into 24-hour traffic volume by using the conversion rate.	October 24	2 survey locations	Not Applicable
TRAVEL TIME SURVEY					
7	Travel Time Survey	To obtain traffic congestion conditions along main roads.	August 11 to August 20	13 routes	Not Applicable

(cont'd)

Table 2.1.1(2) : Traffic Surveys Conducted

Survey No	Survey Type	Purpose	Survey Period	Actual Sample Size	Actual Sample Rate
PUBLIC TRANSPORT SURVEY					
8	Stage Bus Survey				
	(a) Bus Company Survey	To collect data on bus service provision.	August 11 to November 24	5 bus companies	Not Applicable
	(b) Bus Ridership Survey	To determine the bus service of stage buses along each route within the Study Area	August 26 to September 11	33 bus routes	Approximately 10%–25% for each bus route.
	(c) Bus Passenger Interview Survey	To study the characteristics of bus commuters.	August 26	10 bus stations/ stops 623 bus passengers	Not Applicable
9	Factory Bus Survey				
	(a) Factory Management Interview Survey	To obtain information on factory bus services.	September 29 to September 30	32 factories in the Free Trade Zone	Not Applicable
	(b) Factory Bus Interview Survey	To obtain information on factory bus operation and movement characteristics.	October 1 to October 2	100 factory buses in the Free Trade Zone	50%
10	School Bus Survey	To gather detailed information on the characteristics of school bus operations.	October 2 to October 6	70 school buses	22%
11	Taxi Survey	To gather information on taxi operation and movement characteristics.	September 29 to September 30	8 taxi stations 218 taxis	34%
PARKING SURVEY					
12	Parking Survey				
	(a) Parking Supply Survey	To obtain detailed information regarding the provision of parking spaces according to type in each traffic zone within the Central Area.	September 15 to September 19	Central Area of George Town	Not Applicable
	(b) Parking Duration Survey	To determine the parking duration of vehicles, utilisation rate and turnover rate at each parking facility.	October 7 to October 8	14 survey locations	Not Applicable
	(c) Parking Interview Survey	To obtain parking characteristics.	October 7 to October 8	9 survey locations 601 parkers	Not Applicable
LANDUSE SURVEY					
13	Existing Landuse Survey	To obtain landuse characteristics	December 1 to December 5	Central Area of George Town	Not Applicable
PEDESTRIAN SURVEY					
14	Pedestrian Survey	To model the nature and characteristics of pedestrian movement. The results are used in the evaluation and improvement of pedestrian path network, and in the design of pedestrian facilities.	August 19 to August 21	7 survey locations	Not Applicable

2.1.2 Zoning

Zoning for the traffic surveys was based on the following guidelines:

(1) Penang Island Transportation Study conducted by JICA in 1979.

(2) Penang Island Structure Plan

(3) Land Use Pattern

According to these zones, the internal area is divided into eleven (11) large zones and sixty-two (62) small zones. Table 2.1.2 and Figure 2.1.1 show the zoning plan.

Table 2.1.2 : Zone Code Table

Area		Large Zone Code	Small Zone Code
Internal Area	George Town	0	01,02,03,04,05,06,07,08
		1	11,12,13,14,15,16,17
		2	21,22,23,24,25,26,27,28
		3	31,32,33,34,35
		4	41,42,43,44,45,46
		5	51,52,53,54,55
		6	61,62,63,64
	Sub-total	(7 zones)	(43 zones)
	Outer Part of George Town	7	71,72,73
		8	74,75,76
		9	77,78,79,80
		10	81,82,83,84,85,86,87,88,89
	Sub-total	(4 zones)	(19 zones)
	Sub-total	(11 zones)	(62 zones)
External Area		11	91,92
		12	93,95
		13	94,96
		14	93.1,93.2
Total		(15 zones)	(80 zones)

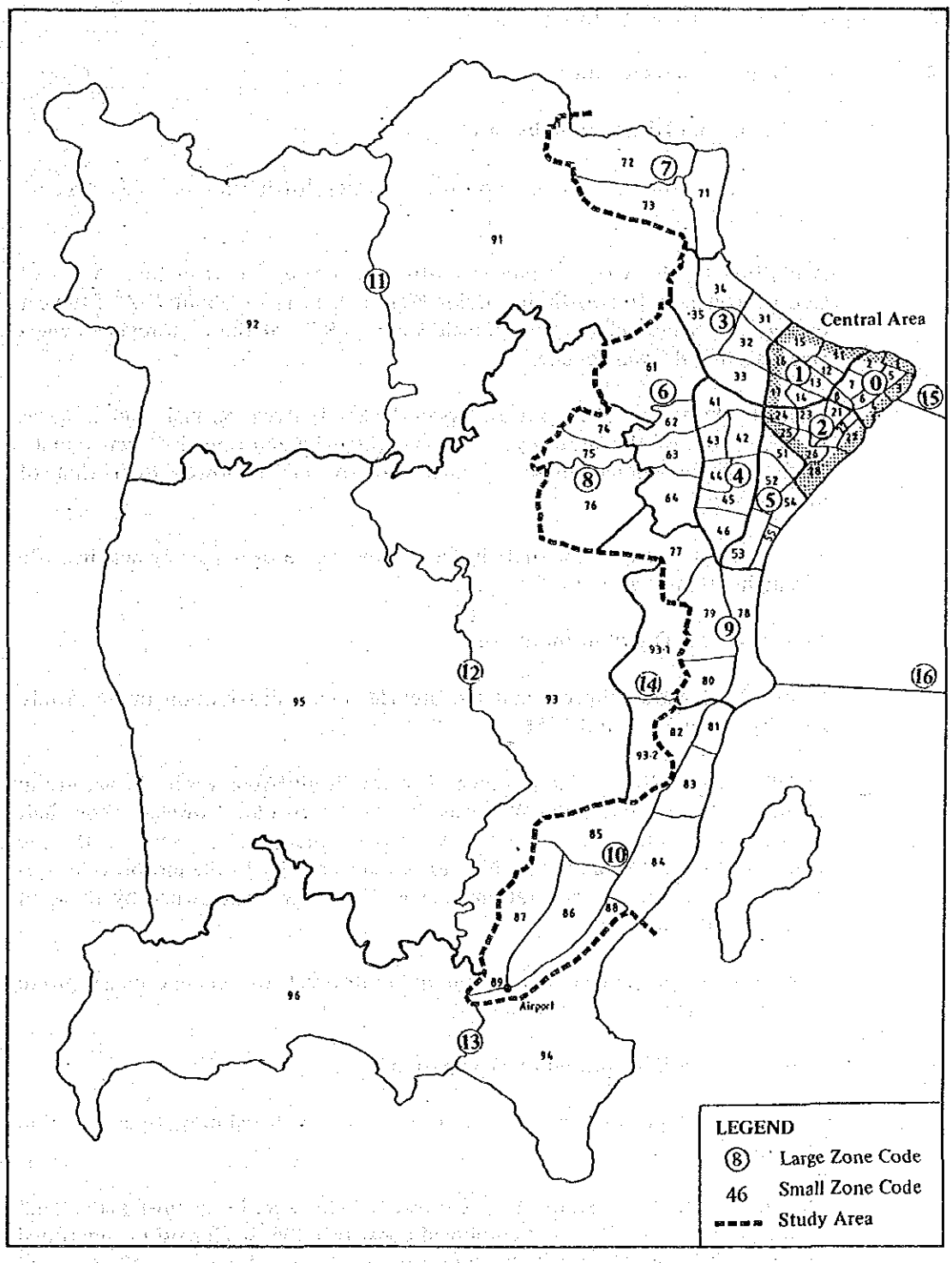


Figure 2.1.1 : Zoning Plan

2.2 Traffic Demand Characteristics

2.2.1 Vehicle Owner's Characteristics

A. Vehicle Owner Distribution by Sex

Figure 2.2.1 shows the car and motorcycle owner distribution in Study Area by sex in 1979 and 1986.

According to the Urban Transport Study in Greater Metropolitan Areas of George Town, Butterworth and Bukit Mertajam in 1979, about 79% of the car owners was male and 21% was female whereas 92% of the motorcycle owners was male and 8% was female.

In 1986, about 77% of the car owners in the Study Area was male and 23% was female. 86% of the motorcycle owners was male and only 14% was female. Thus, the percentage share of male car owners is lower than that of motorcycles.

These figures clearly show that the percentage share of female owners in 1986 was higher than that of 1979.

B. Vehicle Owner Distribution by Age

Figure 2.2.2 shows the car and motorcycle owner distribution in the Study Area by age in 1979 and 1986.

In 1986, about 38% of the car owners in the Study Area was in the age group of 30 – 39 years and about 40% was above 40 years old. However, about half of the motorcycle owners was below 30 years and about 27% was in the age group of 30 – 39 years old. This shows that majority of the motorcycles was owned by the younger generation, that is, about 78% was owned by those of 39 years and below.

Generally, the percentage share of car and motorcycle owners in each age group was almost the same in 1979 and 1986.

C. Vehicle Owner Distribution by Occupation

Figure 2.2.3 depicts the car and motorcycle owner distribution by occupation in 1986.

On the whole, in the Study Area, car owners who were in the professional and technical sector as well as self-employed constitute the two largest occupational group of 17% each. Similarly, motorcycle owners who were self-employed form the largest percentage share of 15%.

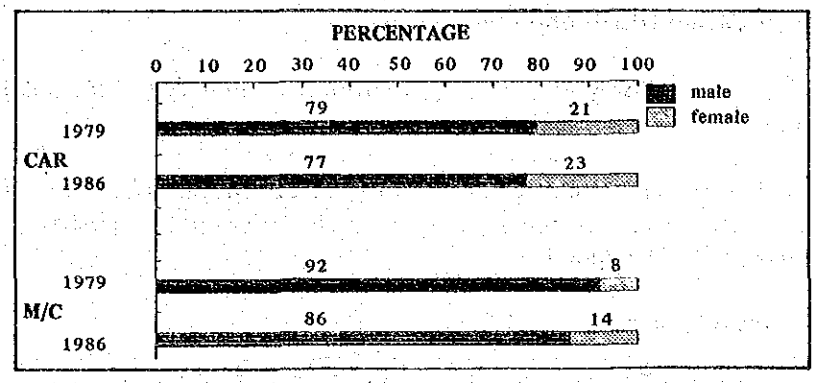


Figure 2.2.1 : Car and Motorcycle Owner Distribution in the Study Area by Sex (1979 & 1986)

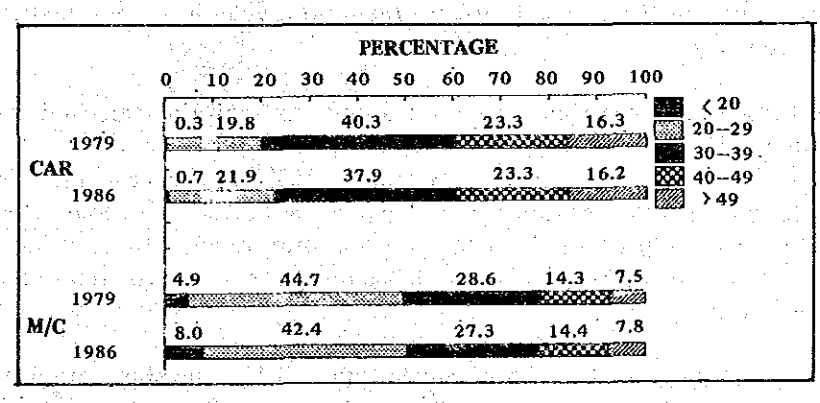


Figure 2.2.2 : Car and Motorcycle Owner Distribution in the Study Area by Age (1979 & 1986)

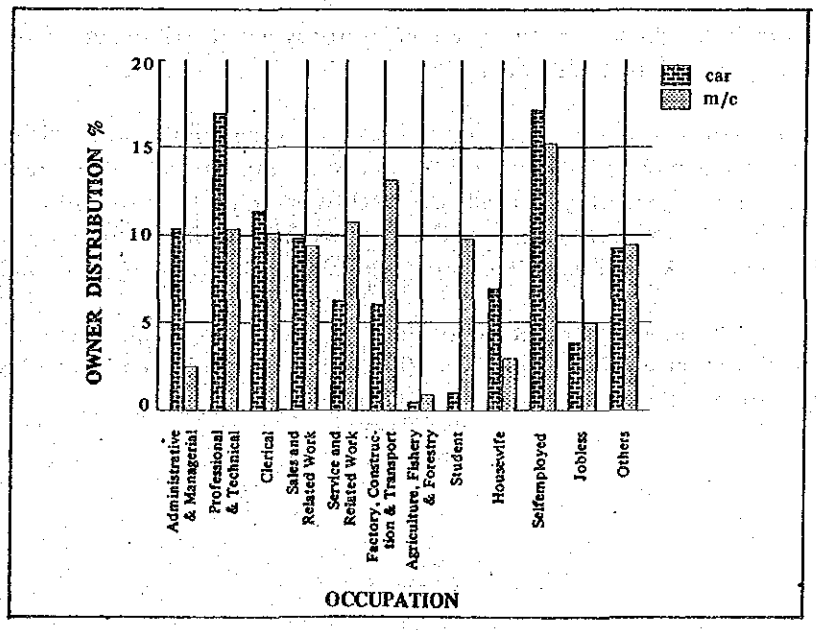


Figure 2.2.3 : Car and Motorcycle Owner Distribution in the Study Area by Occupation (1986)

D. Vehicle Owner Distribution by Industry

The car and motorcycle owner distribution by industry (1986) is illustrated in Figure 2.2.4.

Overall, the major employment sectors for car and motorcycle owners in the Study Area were commerce (18%) and agriculture, forestry and fishery industries (20%) respectively.

E. Ownership Period

Figure 2.2.5 shows the comparison of car and motorcycle ownership period distribution between 1979 and 1986.

About 49% of the cars and 46% of the motorcycles in 1979 were between one to two years.

In 1986, the ownership period of about 23% of the cars and 27% of the motorcycles in the Study Area were between one to two years. On the other hand, the ownership period of about 35% of the cars and 30% of the motorcycles were over four years. This shows that there is not much difference in the ownership period between cars and motorcycles, thereby indicates that the rate of possession of cars is almost the same as that of motorcycles in the Study Area.

The percentage share of both vehicle types with ownership period of three to four years and more than four years was higher in 1986 than 1979.

F. Frequency of Usage Per Week

Figure 2.2.6 illustrates the car and motorcycles distribution by frequency of usage per week in 1979 and 1986.

In the Study Area, in 1986, the percentage of car and motorcycle owners who use their vehicles daily were 77% and 86% respectively. This shows that the frequency of motorcycle usage per week was higher than that of car. However, a slightly higher percentage of the car owners use their vehicles for five to six days per week, that is, 11% compared to 9% of the motorcycle owners.

A slightly lower percentage of the car and motorcycle owners used their vehicles every day in 1979 than 1986. However, a higher percentage of them used their vehicles for five to six days per week.

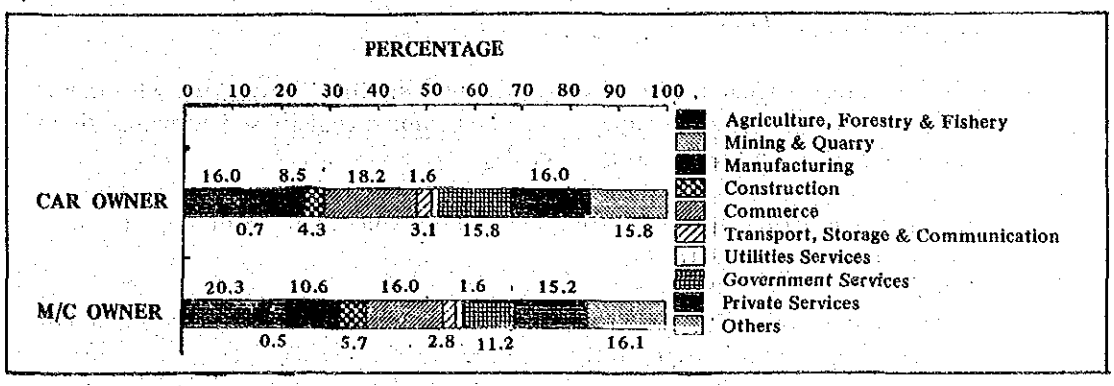


Figure 2.2.4 : Car and Motorcycle Owner Distribution in the Study Area by Industry (1986)

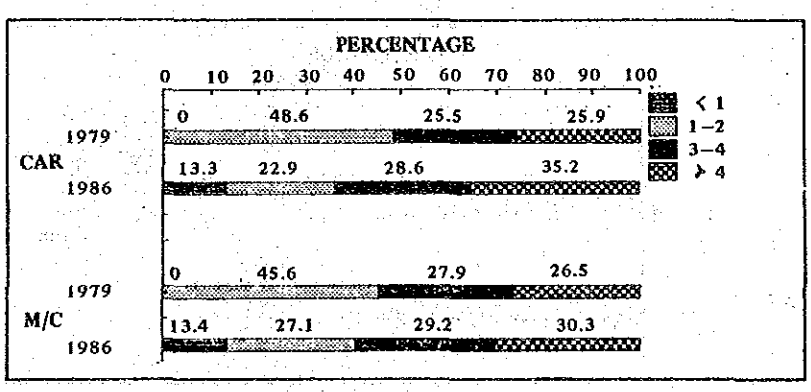


Figure 2.2.5 : Car and Motorcycle Ownership Period Distribution in the Study Area (1979 & 1986)

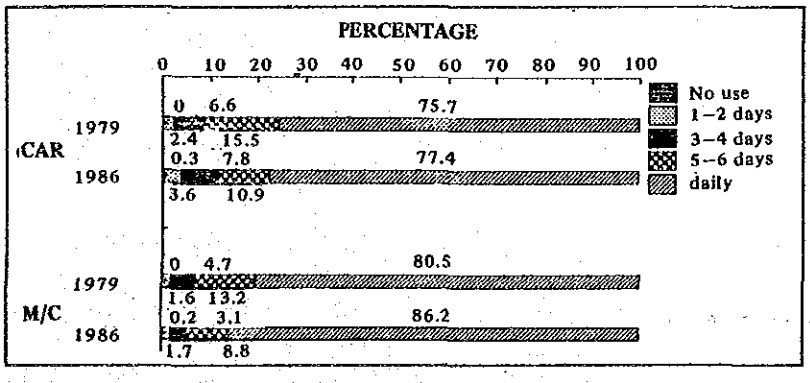


Figure 2.2.6 : Car and Motorcycle Distribution in the Study Area by Frequency of Usage Per Week (1979 & 1986)

G. Number of Trips Per Day

The percentage of car and motorcycle owners in the Study Area who made two trips per day was 40% each. It can be assumed that these people use their vehicles for work and home trips every day.

The proportion of car and motorcycle owners who made four trips per day was 25% and 31% respectively.

The percentage of car and motorcycle owners who made at least one trip a day were 97.2% and 97.8% respectively.

The car and motorcycle distribution by number of trips per day (1986) is shown in Figure 2.2.7.

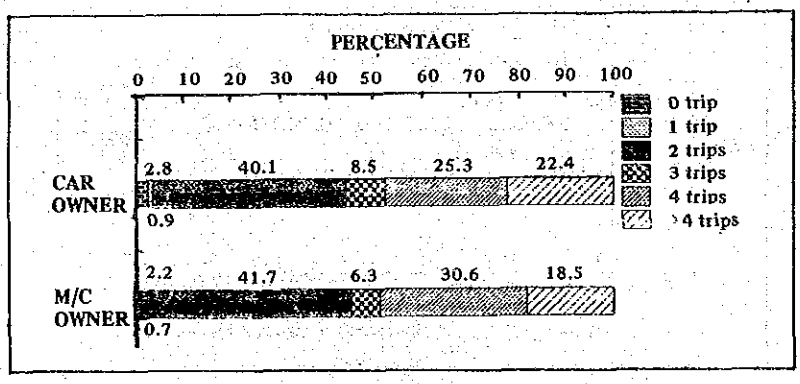


Figure 2.2.7 : Car and Motorcycle Distribution in the Study Area by Number of Trips Per Day (1986)

2.2.2 Trip Production

Based on the Vehicle Owner Interview Survey, the total number of daily internal trips in terms of Passenger Car Unit (PCU) was 481,117 or 87% of the present total trips, whereas the external and through trips was 67,355 (12%) and 5,609 (1%) respectively. Table 2.2.1 shows the trip production.

Among the vehicle types, car had the highest number of trips made, that is 213,732 or 44% of the total number of trips made. Motorcycle constituted 184,807 or 38% of the number of trips made. Taxi, stage bus, factory and school bus accounted for 11% whereas van and pick-up, medium and heavy lorries formed 6% of the total number of trips made. The trip production by vehicle type in the Study Area is depicted in Table 2.2.2.

Table 2.2.1 : Trip Production (1986)

Trip Classification	Trip Production (PCU per Day)	%
Internal Trip	481,117	86.8
External Trip	67,355	12.2
Through Trip	5,609	1.0
Total Trip	554,081	100.0

Table 2.2.2 : Total Trip Production by Vehicle Type in the Study Area (1986)

Vehicle Type	Trip Production (PCU per Day)	%
Car	213,732	44.4
Motorcycle	184,807	38.4
Taxi	3,877	0.8
Factory & School Bus	41,514	8.6
Stage Bus	7,281	1.5
Van & pick-up	12,399	2.6
Medium Lorry	11,312	2.4
Heavy Lorry	6,195	1.3
Total	481,117	100.0

* PCU Conversion Table :

Vehicle Type	PCU
Motorcycle	0.5
Car, taxi, van & pick-up	1.0
Medium lorry	2.0
Heavy lorry, factory, school and stage bus	3.0

Figure 2.2.8 illustrates the composition of car and motorcycle trip production by purpose in the Study Area.

In the Study Area, return to home trips formed the largest portion of car trips, that is, 40%. Private trips constituted 24% whereas trips to work formed 20% of the total number of car trips. Trips for business and school purposes amounted to 8% each.

For motorcycle, the composition share of trip production by each purpose was almost the same as that of car.

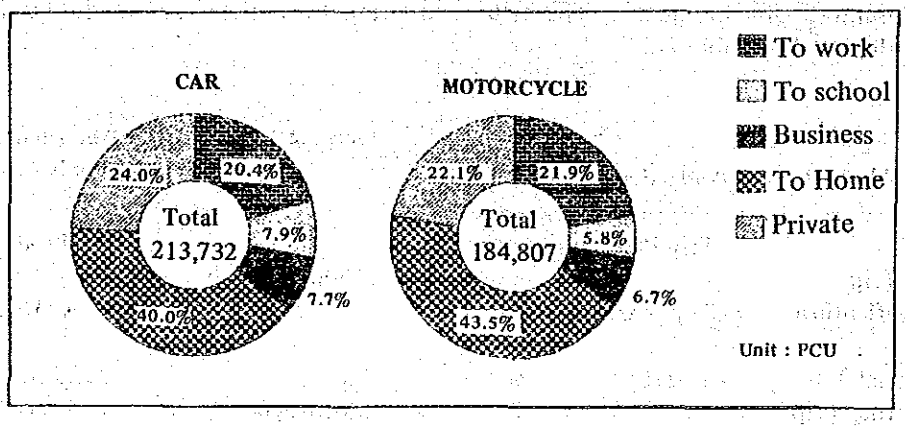


Figure 2.2.8 : Composition of Car and Motorcycle Trip Production by Purpose in the Study Area (1986)

2.2.3 Trip Generation and Attraction

Figure 2.2.9 shows the daily vehicular trip generation and attraction for all purposes by traffic zones in 1986.

It is observed that CBD (Traffic Zone 0) which is bounded by Penang Road, Magazine Road and the sea-front generated and attracted (227,700) the largest number of daily trips. This is due to the fact that it is the core of George Town where administrative, political, shopping, banking, office, hotel, wholesale and retailing activities are found. This is followed by Traffic Zone 1 where the number of trips generated and attracted (124,800) was almost half of that in Traffic Zone 0. Zone 1 is bounded by Penang Road, Dato Keramat Road, Perak Road, Pangkor Road and the sea-front where the main activities are shopping, office and hotel. This is followed closely by Zone 4 where the trip generation and attraction was 106,100.

Generally speaking, the trip generation and attraction by each zone in the Study Area are above 54,000 whereas those outside the Study Area are below 21,000.

Figure 2.2.9 also illustrates the daily vehicular trip generation and attraction for all purposes in George Town in 1979 as obtained from the Urban Transport Study in Greater Metropolitan Area of George Town, Butterworth and Bukit Mertajam.

It can be observed that the trip generation and attraction in George Town in 1986 increased as compared to that in 1979.

2.2.4 OD Distribution Pattern

Figure 2.2.10 illustrates the all vehicles OD distribution pattern for all purposes (1986). For clear illustration, only the desire lines with more than 3,000 trips are shown.

The Central Area has the most internal trip of 109,200 followed by 65,100 in the outer part of George Town.

The Central Area-outer part of Central Area corridor shows the largest number of trip movements (105,900). The second largest amount of trip movements was observed between the Central Area and Zone 8 where a developing new growth centre exists. The desire lines between the Central Area and Zones 7, 9 and 10 in the Study Area had values ranging from 14,400 to 18,300, whereas that of between outer part of the Central Area and outer part George Town ranged from 13,400 to 19,700.

The trip movements between George Town and the mainland is mainly by ferry whereas that of between outside George Town and the mainland is by the Penang Bridge.

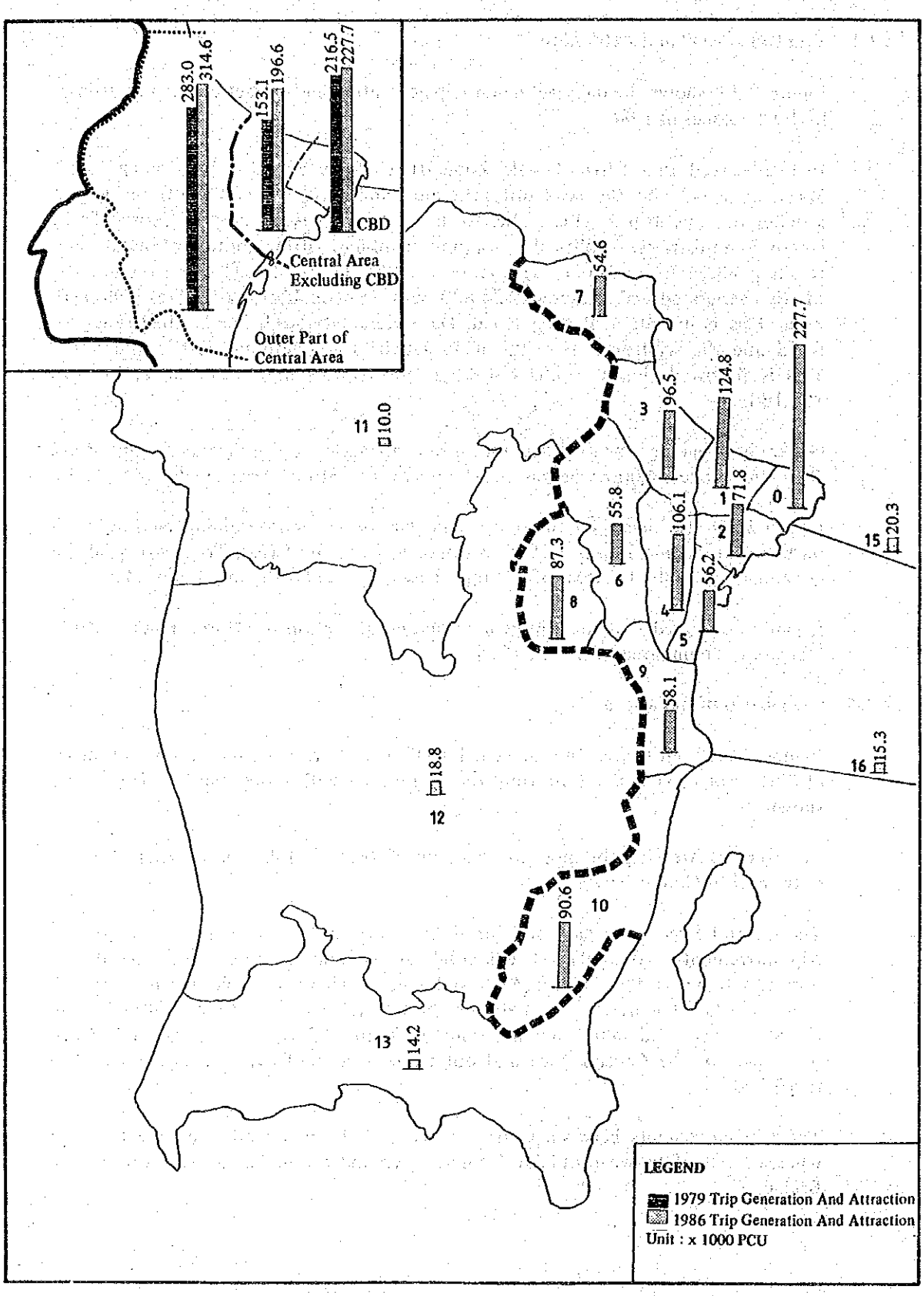
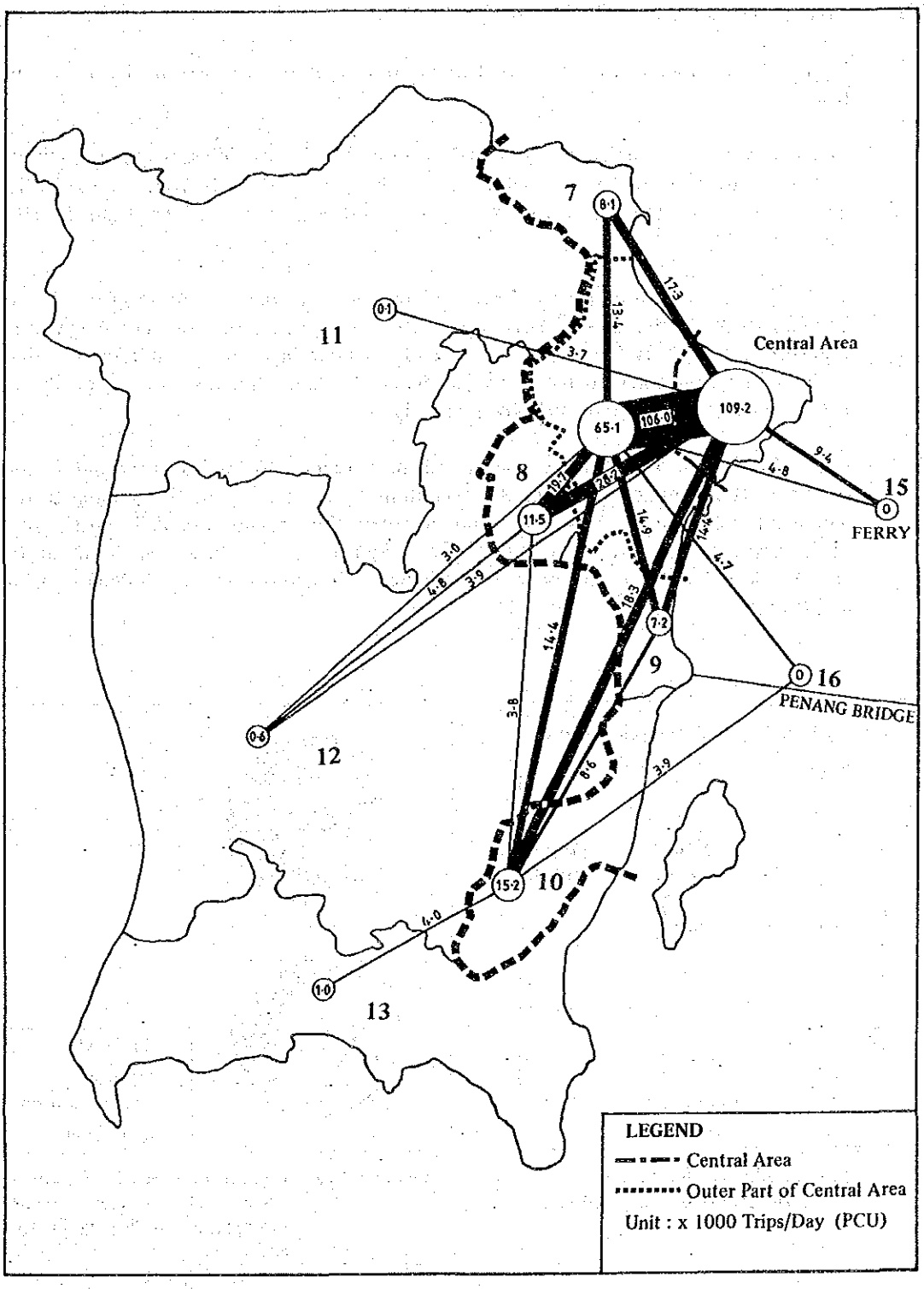


Figure 2.2.9 : Daily Vehicular Trip Generation and Attraction for All Purposes (1979 & 1986)



Note : Present (1986) OD table is shown in Table 3.4.2.

Figure 2.2.10 : All Vehicles OD Distribution Pattern for All Purposes (1986)

2.2.5 Traffic Volume Across The Straits

Figure 2.2.11 illustrates the daily traffic volume across the Straits by Ferry and Bridge.

In 1984, the Ferry carried a daily traffic volume of 30,800. This dropped to 28,700 in 1985. This was due to the opening of the Penang Bridge in September 1985. The daily vehicular volume across the Straits in 1985 of 32,500 was higher than the 1984 value of 30,800.

The daily traffic volume on the Ferry was estimated to have decreased from 28,700 in 1985 to 20,300 in 1986. This is a drastic drop of 29.3%. The vehicular volume was shifted to the Bridge linkage as 13,100 trips per day were estimated. The daily vehicular trip is projected to be 33,400 where the percentage share on the Penang Bridge and Ferry is 39% and 61% respectively.

From the Cordon Line Survey conducted, motorcycles formed approximately 39% of the traffic volume, and vehicles except motorcycle 61% on the Penang Bridge, whereas the composition share of vehicles except motorcycle was 39% and the share of motorcycle was 61% on the Ferry. Figure 2.2.12 shows the comparative composition share of motorcycle and vehicles except motorcycle on Penang Bridge and Ferry.

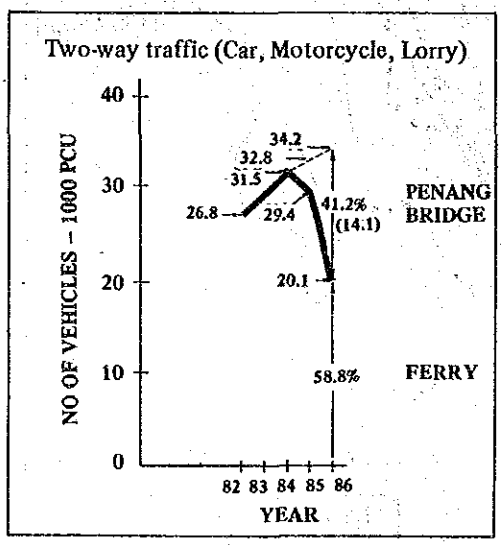


Figure 2.2.11 : Daily Traffic Volume Across the Straits by Ferry and Bridge

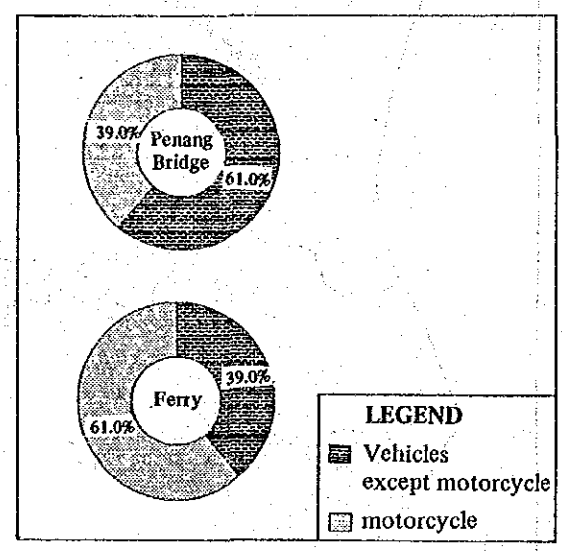
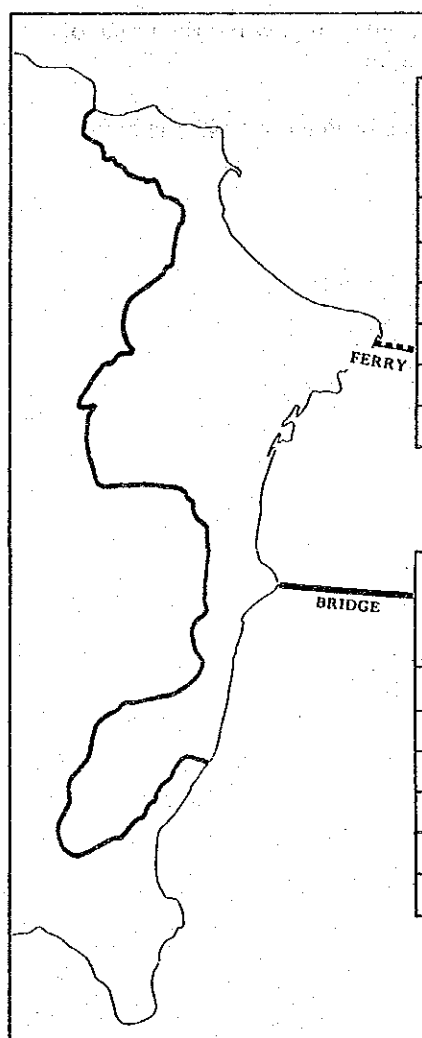


Figure 2.2.12 : Composition Share of Motorcycle and Vehicles except Motorcycle on Penang Bridge and Ferry

Figure 2.2.13 depicts the outbound and inbound trip for car and motorcycle by trip purpose by ferry and bridge in 1986.

For work trip, the number of car users by ferry for outbound trip was more than that of inbound trip. This indicated that there were more people from the island working on the mainland. This travel pattern was also valid for car users by bridge. On the other hand, there were more inbound than outbound car trips for private trip purpose by ferry and bridge. For car users by ferry, the inbound trip was more than twice that of the outbound trips.

For motorcycle users, the outbound work trip was more than the corresponding inbound trip by ferry and bridge but the difference was not as great as that of car users. The number of inbound private trips for motorcycle was more than the outbound trip by ferry as well as the bridge.



	CAR				MOTORCYCLE			
	Outbound Trip		Inbound Trip		Outbound Trip		Inbound Trip	
Trip Purpose	No.	%	No.	%	No.	%	No.	%
Work	1,166	28.4	835	16.5	432	19.6	390	18.7
School	6	0.1	9	0.2	57	2.6	27	1.3
Business	555	13.5	799	15.8	56	2.5	106	5.1
Home	1,699	41.4	1,866	36.9	1,364	61.8	953	45.6
Private	681	16.6	1,548	30.6	297	13.5	613	29.3
Total	4,107	100.0	5,057	100.0	2,206	100.0	2,089	100.0

	CAR				MOTORCYCLE			
	Outbound Trip		Inbound Trip		Outbound Trip		Inbound Trip	
Trip Purpose	No.	%	No.	%	No.	%	No.	%
Work	1,085	22.8	874	20.9	299	31.4	289	37.5
School	14	0.3	0	0.0	8	0.8	56	7.2
Business	976	20.5	591	14.2	49	5.1	28	3.7
Home	1,540	32.2	1,487	35.6	495	52.0	233	30.3
Private	1,154	24.2	1,223	29.3	102	10.7	164	21.3
Total	4,769	100.0	4,175	100.0	953	100.0	770	100.0

Unit : PCU

Figure 2.2.13 : Outbound and Inbound Trip for Car and Motorcycle by Trip Purpose by Bridge and Ferry, 1986

2.2.6 Person Trips by Transportation Mode

The Vehicle Passenger Occupancy Survey indicated that a total of 343,450 person trips per 12 hour period crossed the Inner Cordon Line. Out of the total trips, 77% of them travelled in private vehicles, 13% used stage buses and 10% used other buses (including factory/school bus).

Figure 2.2.14 depicts the directional traffic volumes and passengers by transportation mode.

Direction wise, many persons travelled from the west to the CBD and vice versa by using mainly Dato Keramat Road. 17% travelled in buses, 25% if we include those who used factory/school buses.

When compared with Kuala Lumpur, it is observed that:

(1) The usage of cars is higher in Kuala Lumpur than in Penang, while the usage of motorcycles is higher in Penang than in Kuala Lumpur.

(2) The usage of buses including factory/school buses in Penang (24%) is almost the same as that of Kuala Lumpur (25%).

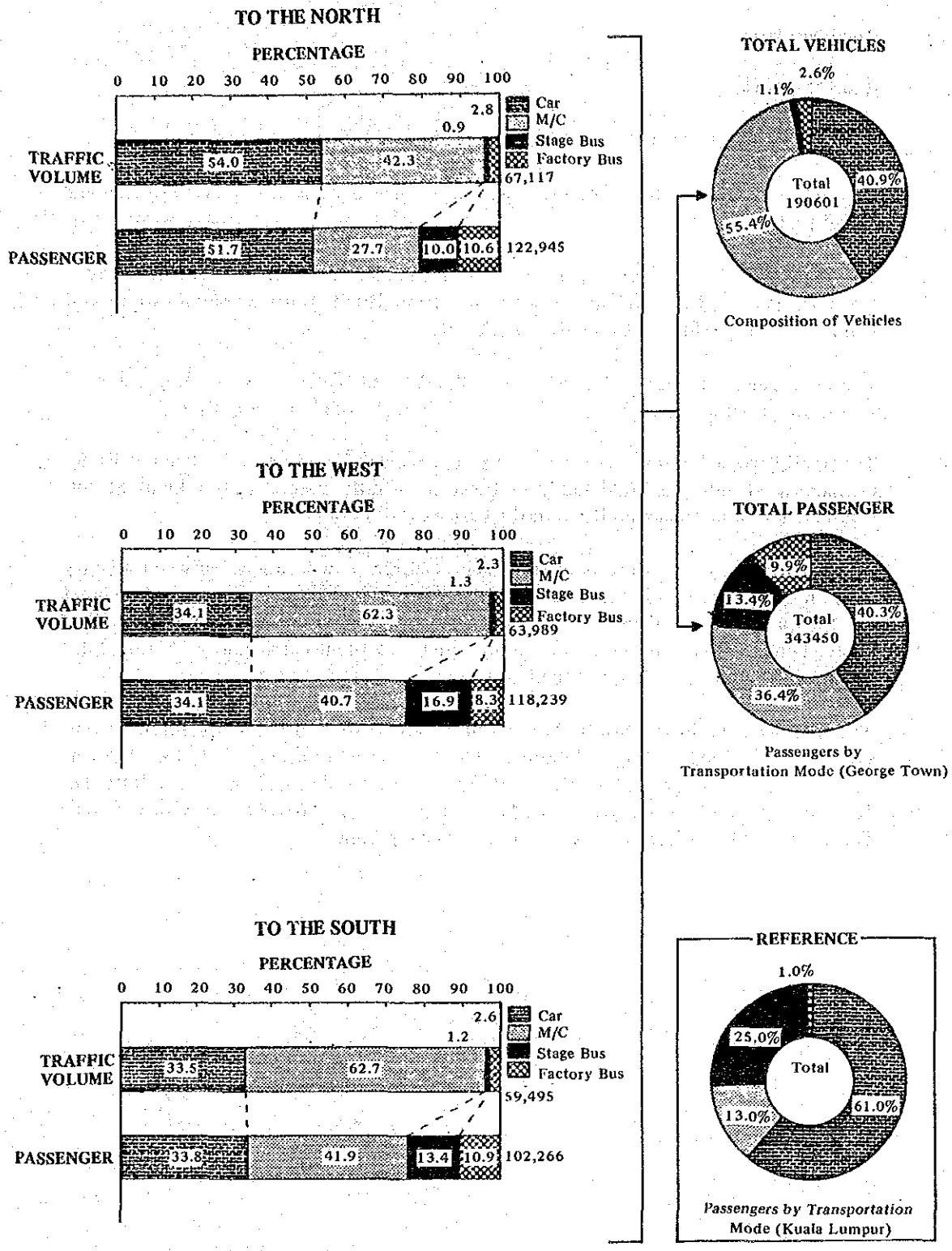


Figure 2.2.14 : Directional Traffic Volumes and Passengers by Transportation Mode

2.3 Road Network

2.3.1 Road Network

Figure 2.3.1 illustrates the present road network.

In George Town, the road network pattern is formed by a combination of ring and radial roads.

The main radial roads running into the Central Area are : in the north, Kelawei Road–Northam Road, from the west, Air Itam Road–Dato Keramat Road; and from the south, Jelutong Road–Bridge Street.

The main ring roads are : Green Lane-Scotland Road–Gottlieb Road–Bagan Jermal Road, Sungai Pinang Road–Perak Road, and Prangin Road–Penang Road.

The main arterial street network in the town centre consists of : Penang Road, Carnarvon Street and Weld Quay in the north-south direction, and Light Street, Chulia Street and Magazine Road in the east-west direction.

The right-of-way of the main roads in George Town ranges between twenty (20) and twenty-two (22) meters in width. The number of lanes is mostly two lanes for the passage of vehicles, except for a few streets, such as Ayer Itam Road, Weld Quay, Penang Road and Magazine Road which are 4-lane carriageway. Figure 2.3.2 illustrates the lane number and right-of-way.

The intersections in the Study Area are largely classified into T-shape intersections, cross intersections and roundabouts. Grade-separated intersections like flyovers are located at Green Lane-Gelugor Road and Bayan Lepas Road–Tun Dato Dr. Haji Awang Road. Recently, two flyovers have being constructed at Green Lane–Scotland Road and Hamilton Road–Batu Lancang Lane.

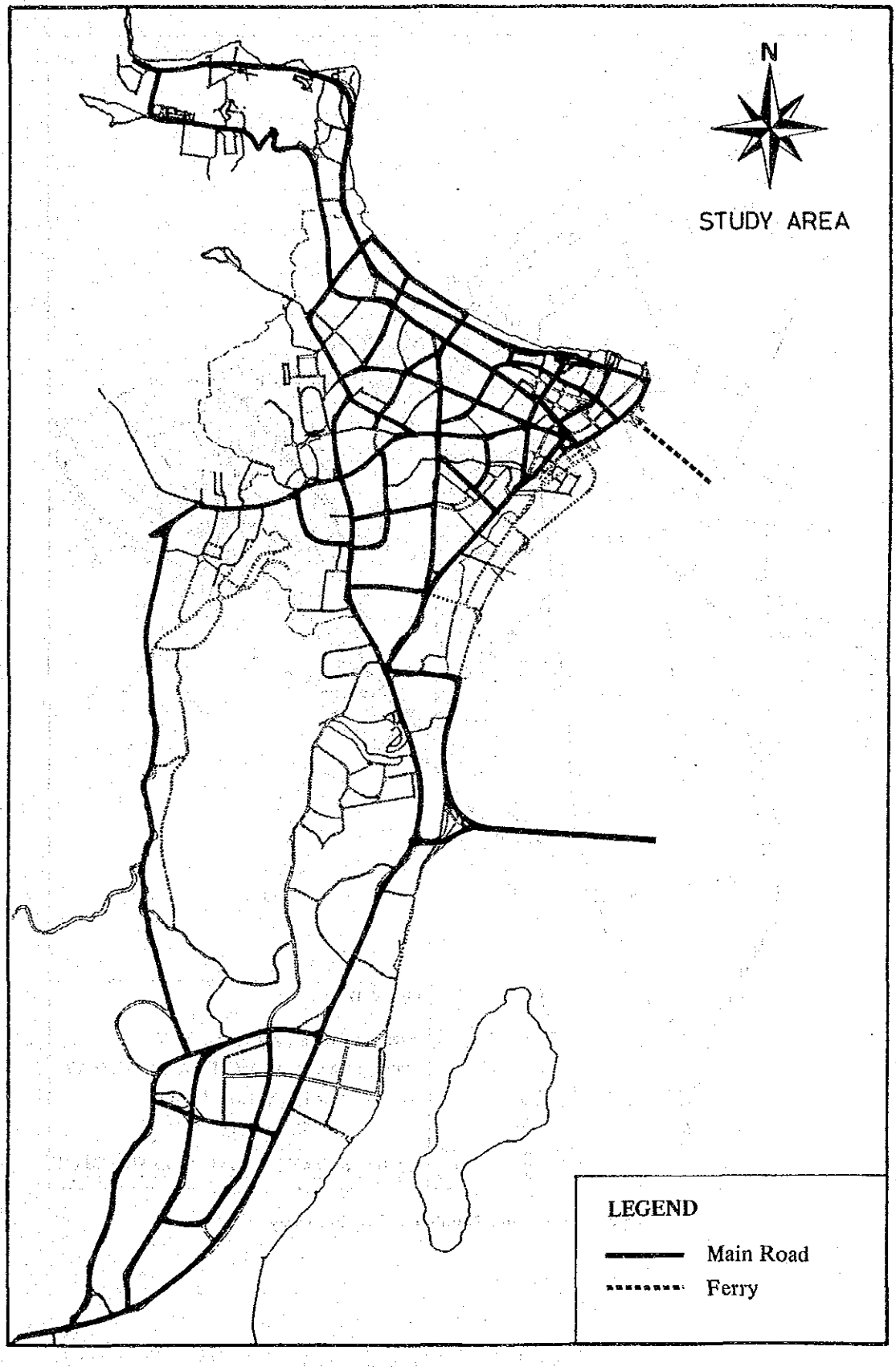


Figure 2.3.1 : Present Road Network

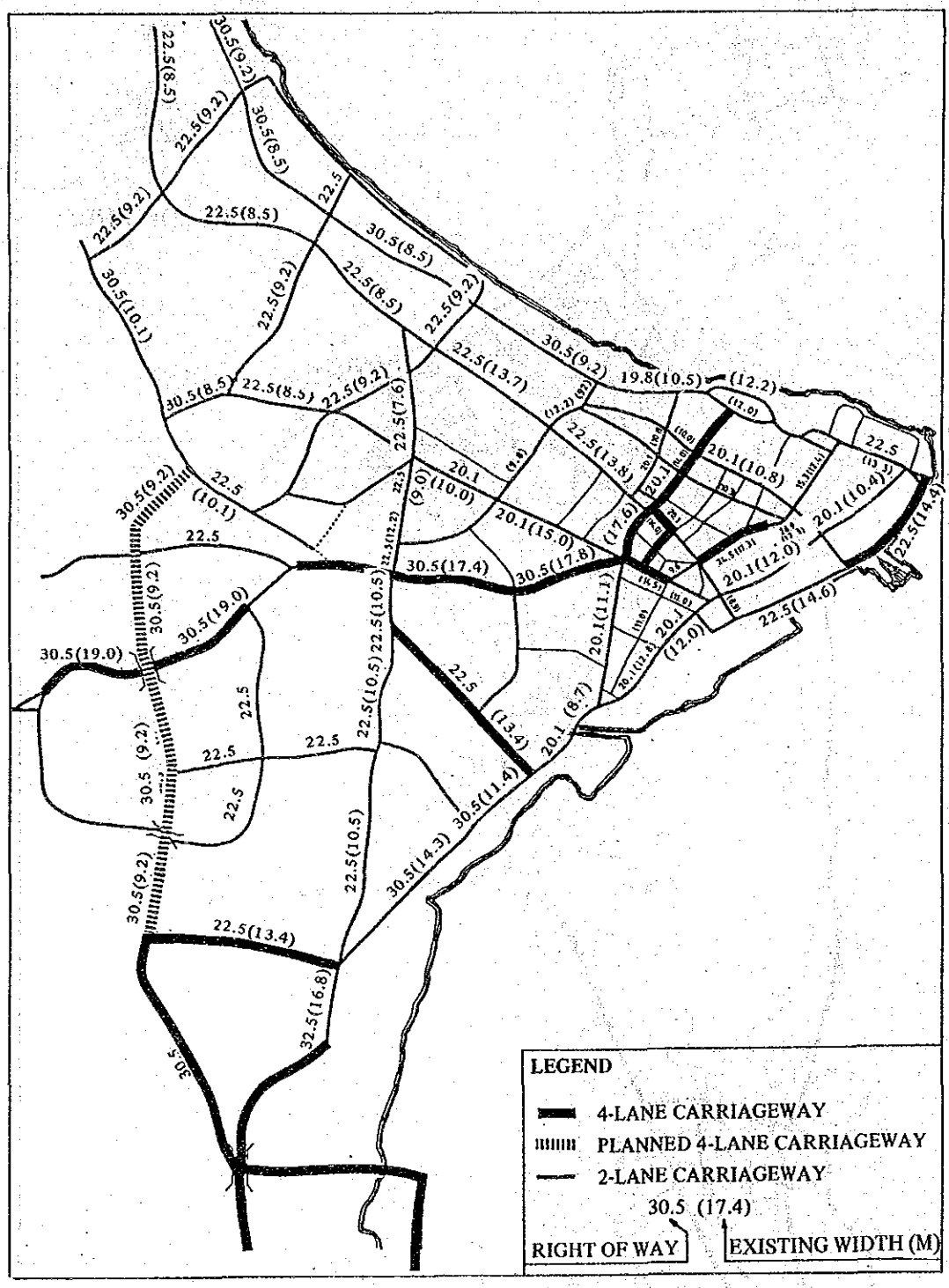


Figure 2.3.2 : Lane Number and Right-of-way

2.3.2 Traffic Condition

A. Traffic Flow on Road Network

By observing the traffic flow pattern on the road network, it is easily perceived that there are obvious traffic corridors connecting the Central Area and the outlying areas. The major traffic corridors in George Town are Northam Road, Dato Keramat Road, Ayer Itam Road, Jelutong Road and Gelugor Road. This is followed by Green Lane, Macalister Road and Burma Road where quite a significant traffic volume is recorded. In addition, heavy traffic is concentrated in the circulation system around KOMTAR. Figure 2.3.3 illustrates the 12-Hour major traffic flow in number of vehicles in George Town.

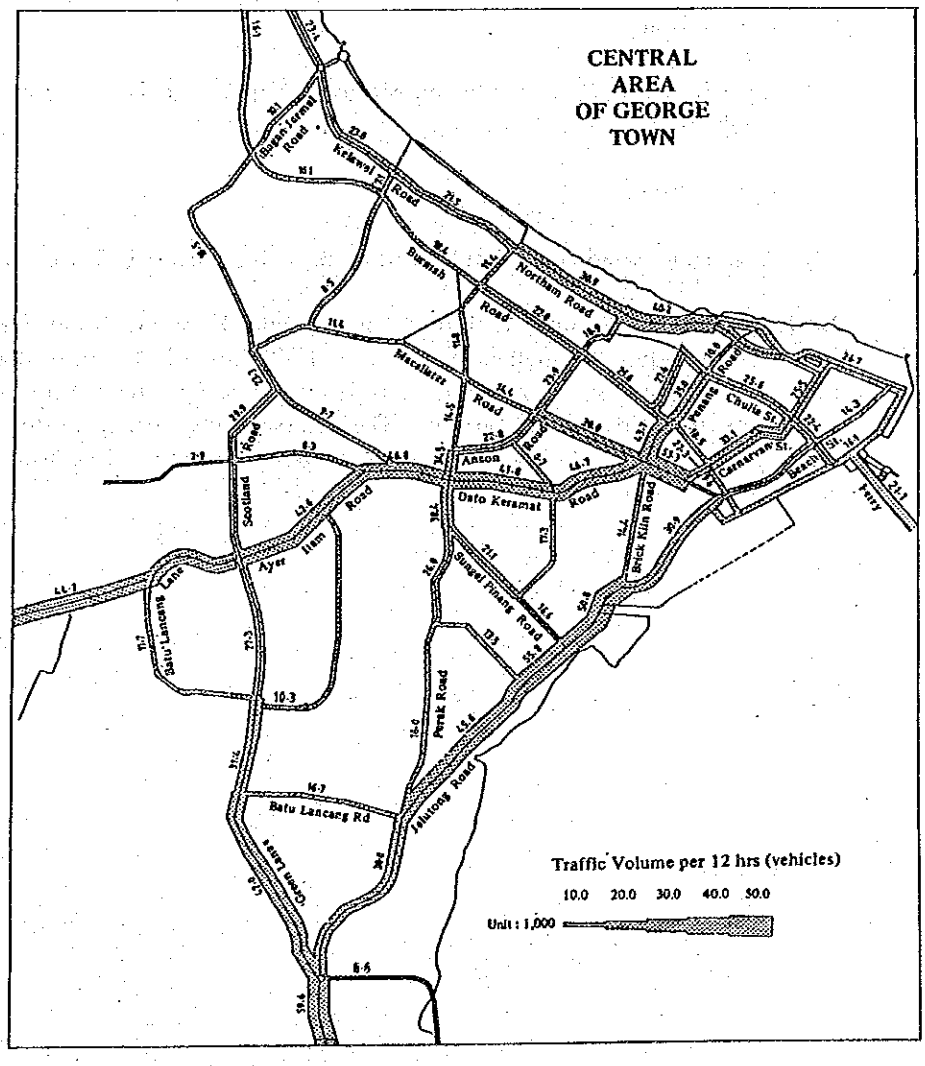


Figure 2.3.3 : 12-Hour Major Traffic Flow in George Town (Unit : Vehicles)

B. Delay Time

To assess the extent of congestion for either along stretches of road or at intersections, delay time analysis is useful to pinpoint some locations with long delay.

Figure 2.3.4 shows the total delay time in hours on major roads in George Town and Ayer Itam for one hour during evening peak hour period.

From this figure, the following stretches of road have shown long delay time :

(1) Bridge Street and Jelutong Road (Between Sungai Pinang Road and Prangin Road)

(2) Carnarvon Street

(3) Prangin Road

(4) Anson Road

(5) Dato Keramat Road (Between Magazine Circus and Dato Keramat Road/ Perak Road intersection)

(6) Penang Road

(7) Ayer Itam Road (Between Kampung Baru and Thean Teik Road)

In terms of delay time at intersections, Dato Keramat Road/Perak Road intersection shows the highest delay time of 379 hours in the morning and 787 hours in the evening. In general, there is an increase in delay time in evening peak hour for all the intersections. The intersections with total delay time of more than fifty (50) hours for both morning and evening peak hour are listed in Table 2.3.1.

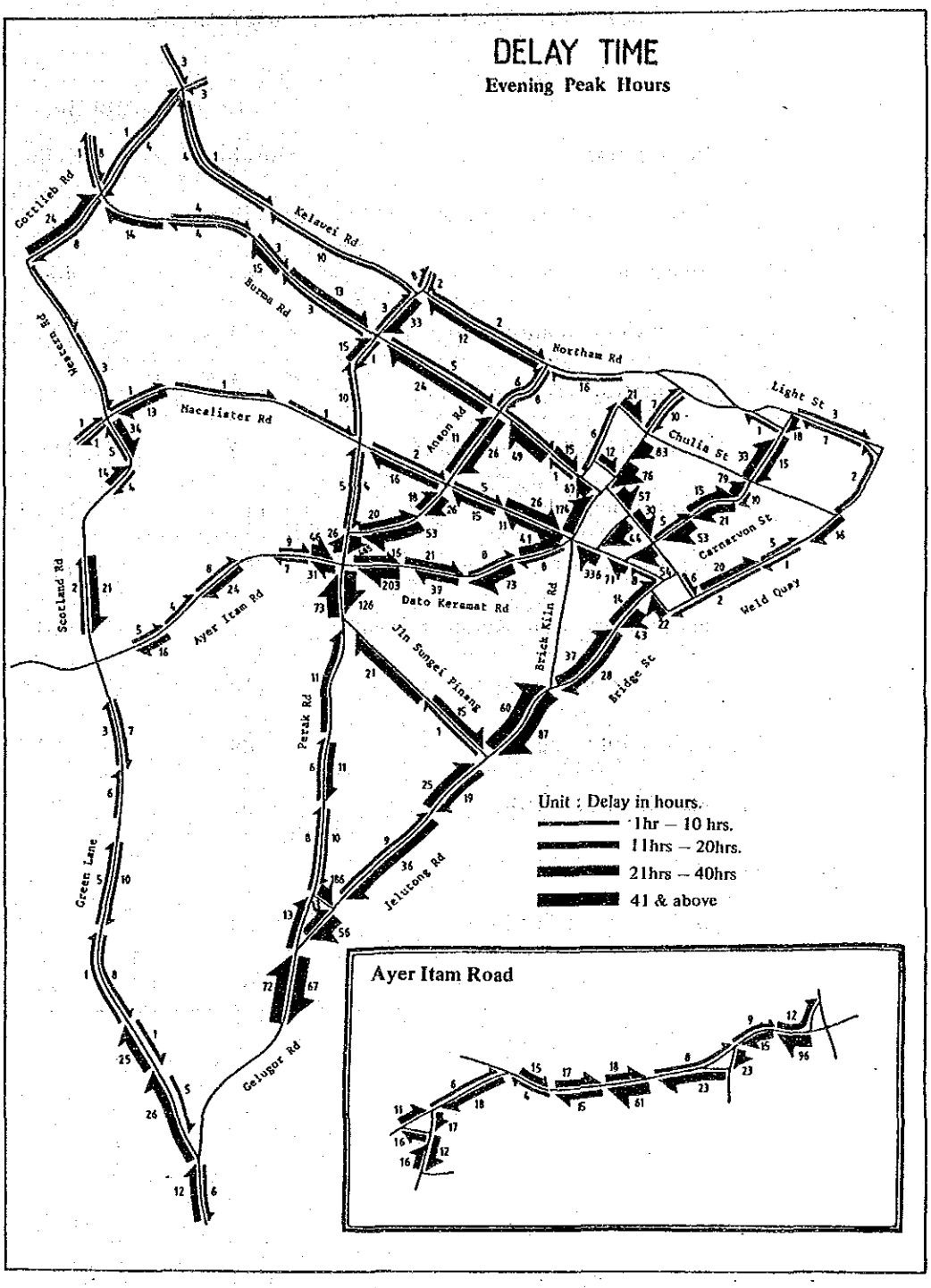


Figure 2.3.4 : Delay Time on Major Roads in George Town and Ayer Itam during Evening Peak Hours

Table 2.3.1 : Major Intersections With Long Delay Time

Intersection	Delay Time In Hours	
	Morning	Evening
1. Perak Road/Dato Keramat Road	379	787
2. Magazine Circus	186	403
3. Perak Close/Jelutong Road	124	235
4. Burma Road/Penang Road	160	174
5. Perak Road/Sg Pinang Road	61	158 *
6. Perak Road/Jelutong Road	117	128 *
7. Jelutong Road/Sg Pinang Road	52	127
8. Patani Road/Dato Keramat Road	52	94 *
9. Chulia Street/Pitt Street	114	93 *
10. Carnarvon Circus	89	83 *
11. Macallum Street/Bridge Street	67	80 *
12. Burma Road/Anson Road	61	73
13. Bishop Street/Pitt Street	53	51 *
14. Gottlieb Road/Burma Road	64	50

* Delay time not including all approaches.

2.3.3 Traffic Signal and Traffic Control Conditions

A. Traffic Control Signals Prior to Stage I ATC System

1. Type of Traffic Signals

Prior to the implementation of the Stage I ATC System, there were thirty-eight (38) sets of traffic control signals in George Town. In addition, five (5) sets of traffic control signals are located outside the city.

The types of traffic control signals used are :

(1) Two-phase pre-timed traffic signals (5 locations)

(2) Two-phase pre-timed traffic signals co-ordinating three (3) intersections (3 locations)

(3) Fully actuated signals with three (3) or four (4) phases (22 locations)

(4) Pedestrian signals actuated by push buttons (6 locations)

(5) Pedestrian signal co-ordinating vehicle signals (1 location)

(6) Vehicle signal controlled by operator for access to/from the ferry terminal (1 location)

Figure 2.3.5 shows the different types of signals at several locations.

2. Installation of Traffic Signals

To preserve the aesthetic beauty of the city, an underground wiring method is used for cable installation and a loop-coil type of vehicle detector adopted instead of an ultrasonic type.

Two types of signal lamp poles are used in the city : the overhead pole with arm and the short vertical pole (Pedestal pole). The short vertical pole is installed at the near-side of all intersection approaches as the primary signal and at the far-side of some intersections as the secondary signal, while the arm-type pole is used at the far-side of important and critical intersections as the secondary signal.

Also, at important and critical intersections, right-turn lanes and traffic signal with green arrows are provided for turning traffic.

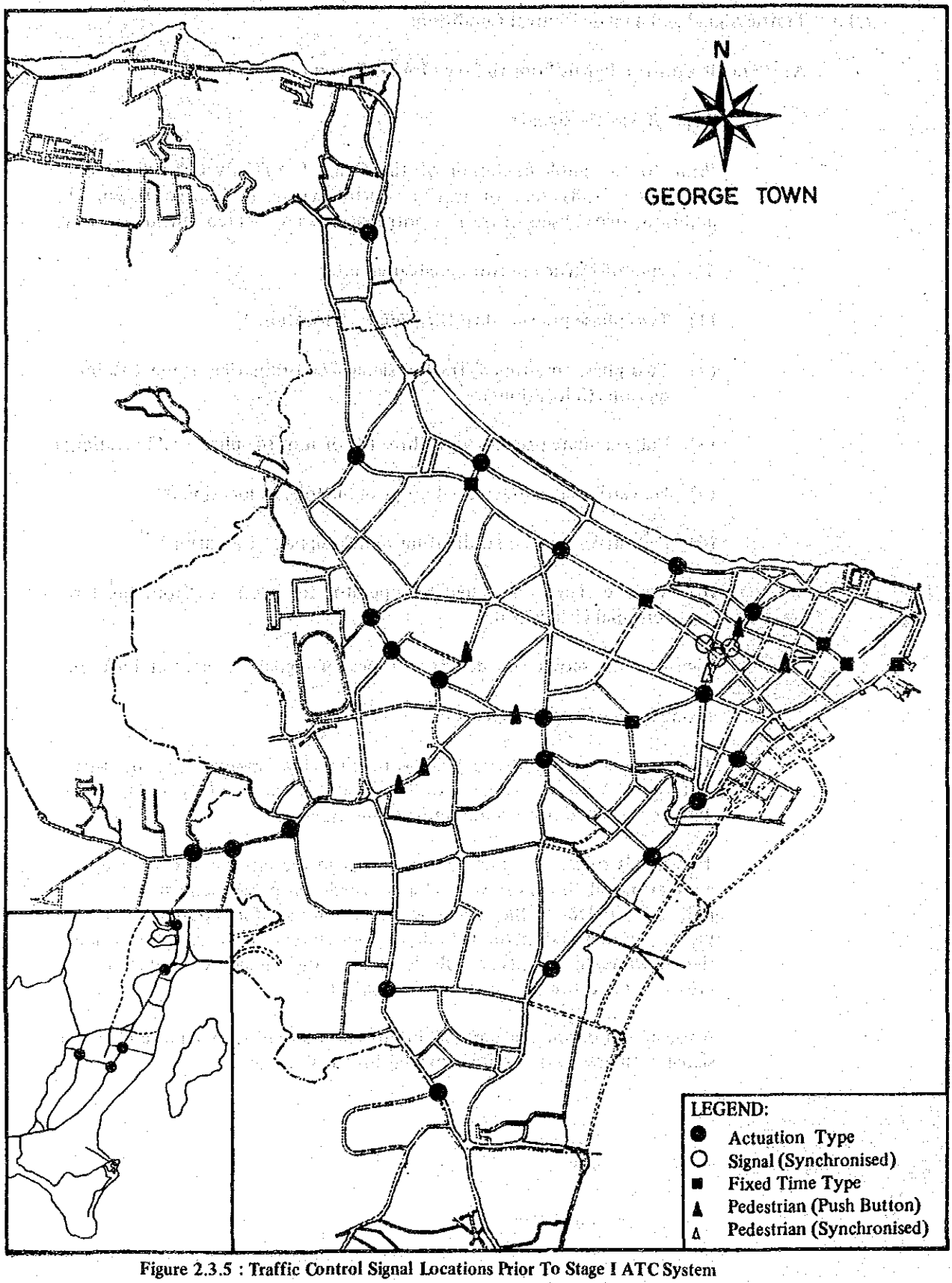


Figure 2.3.5 : Traffic Control Signal Locations Prior To Stage I ATC System

3. Problems of Signal Control Prior to Stage I ATC System

a. Two Phase Pre-timed Traffic Signals

The five (5) simple pre-timed traffic signals were installed almost 15 years ago. As traffic increases, this type of signal does not work effectively. The intersections with this type of traffic signals are listed below :

(1) Intersection of Chulia Street/Beach Street
(2) Intersection of Chulia Street/Pitt Street
(3) Intersection of Dato Keramat Road/Patani Road
(4) Intersection of Burma Road/Larut Road/Anson Road
(5) Intersection of Burma Road/Cantonment Road

The disadvantages of this type of signal are :

(1) The length of cycle and split cannot be adjusted according to the variations of traffic demand.

(2) Two phase signal causes delay for right-turning traffic.

(3) The old signal are too small and dark to give clear vision.

(4) This type of signal decreases intersection capacity and causes undue delay during high volume periods.

b. Two-phase Pre-timed Traffic Signal Co-ordinating Three Intersections

The three sets of signals at the following intersections are linked by cables and the signal-phase is synchronised.

(1) Intersection of Penang Road/Kimberley Street/Phee Choon Street

(2) Intersection of Penang Road/Prangin Road/Burma Road

(3) Intersection of Burma Road/Transfer Road

The distance between intersection (1) and (2) is forty (40) meters and between intersection (2) and (3) is thirty (30) meters.

Signal-green phase priority is given to the south-bound traffic along Penang Road, west-bound traffic along Burma Road, and north-bound traffic along Transfer Road.

Observations on these signals are:–

(1) Green period priority is not given to north-bound traffic moving from the southern section of Penang Road to Transfer Road.

(2) The length of cycle and split cannot be adjusted according to the variation of traffic flow. Thus, congestion levels of the north and south-bound traffic along Penang Road are very different; it is observed that north-bound traffic is always congested.

c. Fully-actuated Signal Control

Traffic-actuated control units permit the cycle length and split to vary according to moment-by-moment traffic counts by vehicle detectors placed in the road-way at approaches to the intersection.

This type of signal control minimizes unnecessary stoppage time and usually reduces delay. It is effective and efficient for use at intersections of the city, especially during low volume periods.

However, under heavy traffic flow conditions, the maximum limits on each green phase will occur frequently and at this time, the signal has the same function as a pre-timed signal control.

Thus, there are some problems at critical intersections during high volume periods, for example, intersection of Dato Keramat Road/Perak Road and intersection of Western Road/Scotland Road.

Also, actuated signal controls are not operated in a link or an interconnected manner with other signals along the route, for example, the series of intersections at Anson Road/Perak Road, Perak Road/Dato Keramat Road and Perak Road/Sungai Pinang Road.

Some detectors for actuated signals do not work. The MPPP seldom checks or maintains the detectors installed under the roads. Thus, it is doubtful whether the actuated signal works effectively. When the detector function fails, the signal control is equivalent to a fixed-time signal control.

d. Pedestrian Signals Actuated by Push-buttons

This type of pedestrian signals actuated by push-buttons is used in front of schools, hospitals and stadium along major roads.

Pedestrians use this type of signal regardless of traffic flow. Thus, traffic flow is often interrupted by the pedestrian signals, increasing undue delay on major roads, especially Dato Keramat Road.

e. Other problems

(1) The short distance between signalised intersections necessitates well-coordinated operation in order to get effective performance.

(2) Adjustment of control timings for signal control on-the-spot is very troublesome. So, it is almost impossible to maintain the optimum control timing constantly.

(3) When malfunction of traffic signal controller happens, serious traffic problem arises.

(4) The city has spent a lot on traffic-control signals. Since most of the energy budget is used for operation of signals, it is worth considering the introduction of dimming of traffic signals and use of energy-saving lamps as some energy-saving devices are readily available.

B. Computerised Area Traffic Control (ATC) System – Stage I

The Stage I ATC System which MPPP has already implemented consists of :

(1) Centralised signal system controlling sixteen (16) intersections, of which two (2) mid-block signals for pedestrians are included.

(2) Closed Circuit Television (CCTV) System controlling two (2) cameras installed at key locations.

(3) Channelization and geometric improvements at major intersections.

(4) Lane markings and traffic signs.

All the signals are located within the area bounded by Anson Road, Perak Road and Sungai Pinang Road. Figure 2.3.6 depicts the signal locations for Stage I ATC System.

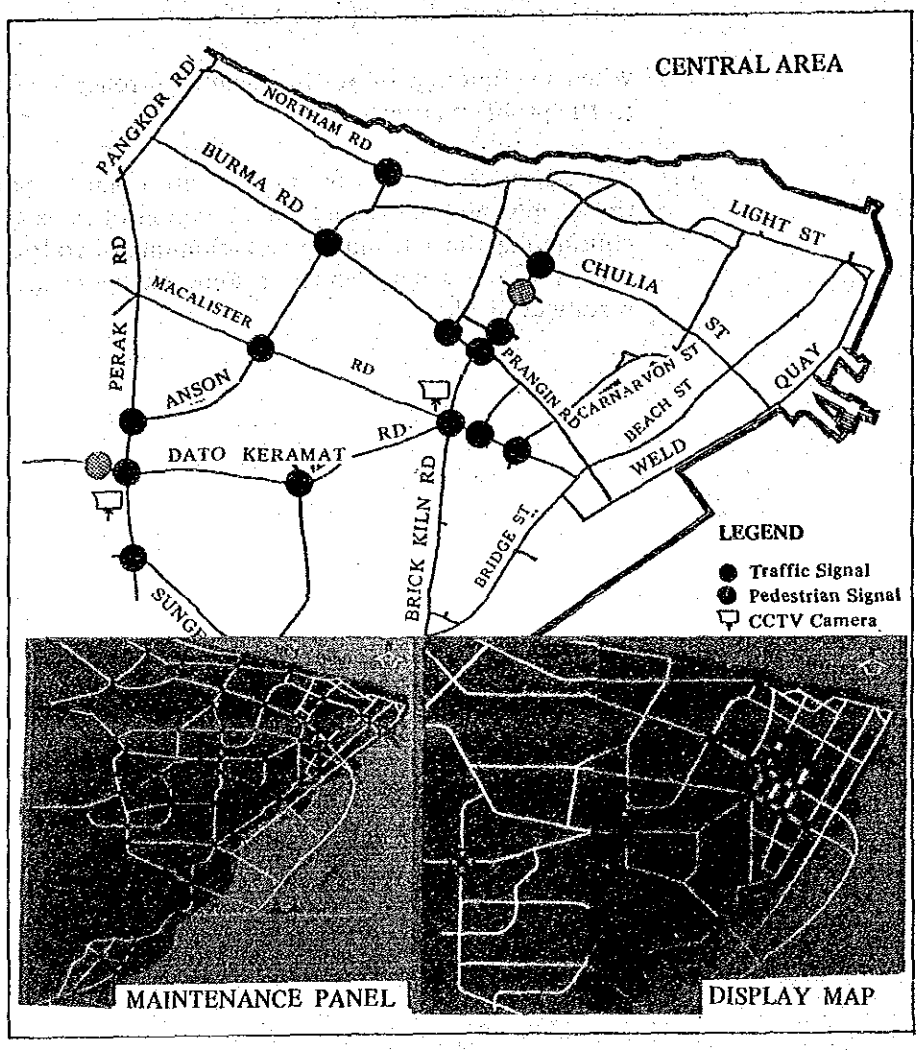


Figure 2.3.6 : Signal Locations in Stage I ATC System

2.3.4 Traffic Accident

According to analysis of the traffic accident record, the number of traffic accident in George Town in 1985 was 5,856 and its related deaths was 103.

The analysis of accident records was carried out separately into intersections and stretches of road. High accident locations are identified based on the number of accidents for intersection and number of accident per kilometer for stretches of road.

Figure 2.3.7 shows the number of accidents at major intersections in George Town. The following intersections have the highest number of accidents.

Intersection	Number of Accidents
(1) Green Lane/Ayer Itam Road	44*
(2) Dato Keramat Road/Perak Road	34
(3) Green Lane/Gelugor Road	33
(4) Burma Road/Gottlieb Road	28

* The data were obtained under the signalized intersection. However at present, a flyover has been constructed.

Figure 2.3.8 depicts the composition of collision pattern. Car/motorcycle collision is predominant with the share of fatal, injured and total accidents at 17%, 41.7% and 30.7% respectively.

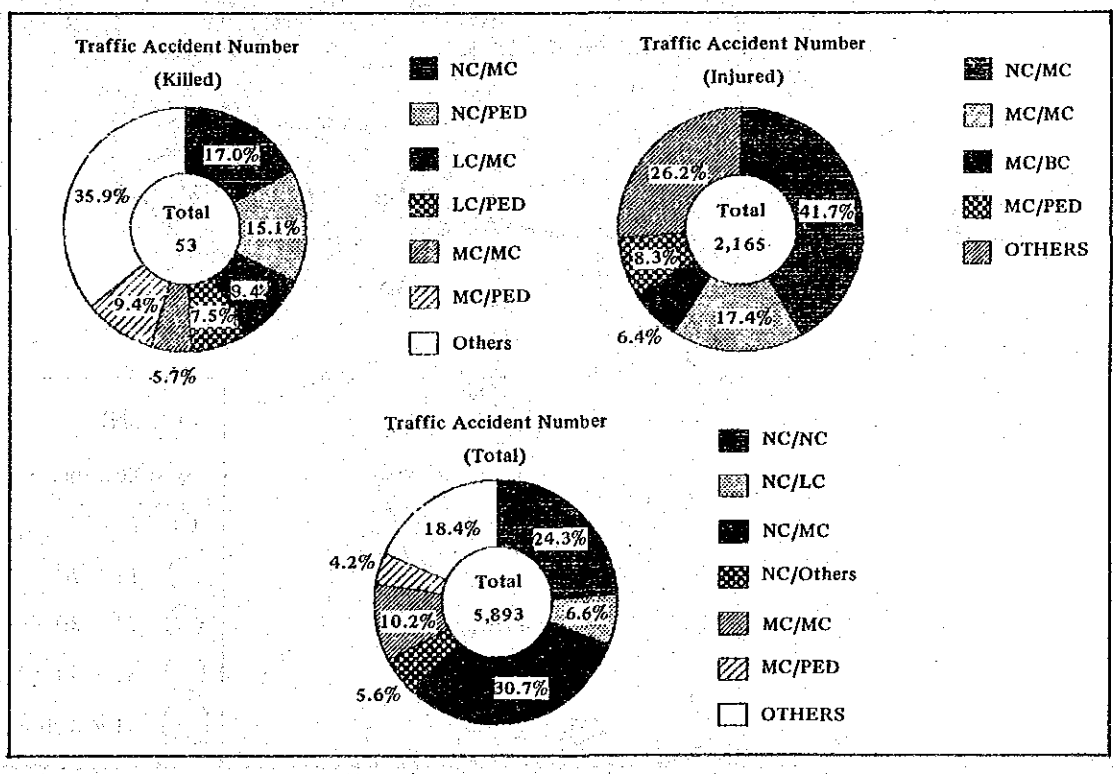


Figure 2.3.8 : Analysis of Collision Pattern

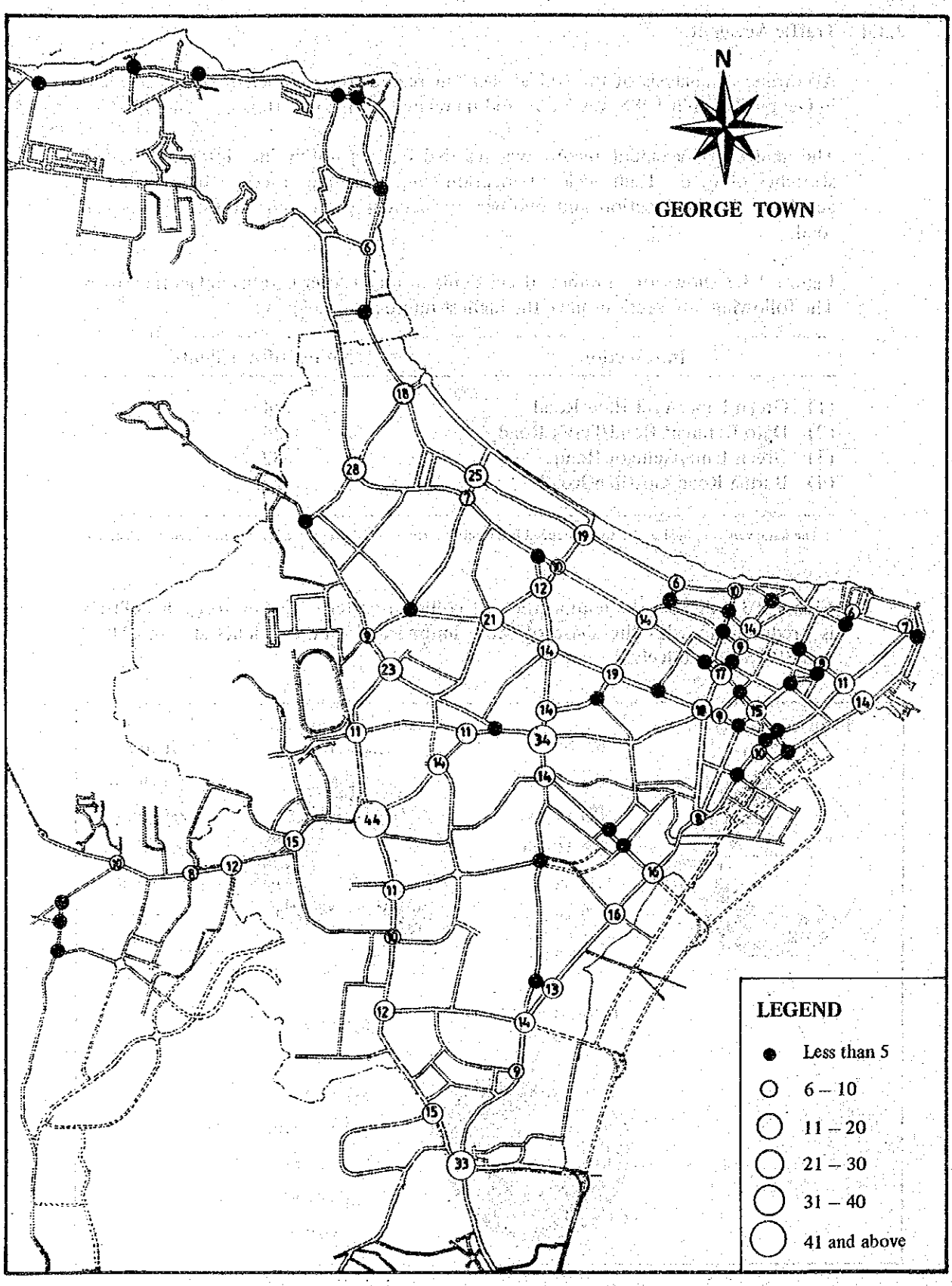


Figure 2.3.7 : Number of Accident at Major Intersections in George Town

2.3.5 Problems on Road Network

A. Road Network

1. Inefficient Geometic Design On Major Roads

Despite a radial-ring road pattern in this city, the major roads do not play their individual functional roles due to inadequate road width, ineffective alignment and irregular intersection geometrics.

2. Inadequate Geometric Designs of Intersections

Traffic flow is interrupted at the following type of intersections :

(1) intersections with irregular features
(2) small roundabouts with heavy traffic volume
(3) many minor accesses along major roads

3. Low Road Capacity

The right-of-way of the main roads in George Town ranges between twenty (20) and twenty-two (22) meters in width. However, the number of lanes is mostly two lanes for the passage of vehicles, except for a few streets such as Ayer Itam Road, Weld Quay, Penang Road and Magazine Road.

B. Traffic Management

1. Lack of Proper Signal Control

At many unsignalised intersections, traffic jam are almost uncontrollable. Signalisation of these intersection is necessary.

Besides this, signal operation does not performed efficiently and effectively at some signalized intersections.

2. Unclear Demarcation

Centreline, lane-line markings, and channelization markings at intersections are worn out in many places, especially on the roads outside the Centra Area where vehicles move at high speed.

3. High Traffic Concentration in Traffic Circulation System around Komtar

Most traffic entering into the Central Area is concentrated around KOMTAR, particularly the short roadway sections on Magazine Road (between Ria Road and Penang Road), and Penang Road (between Kimberley Street and Burma Road). Consequently, these sections are frequently congested due to the heavy traffic volume as well as an enormous weaving traffic movement as illustrated in Figure 2.3.9.

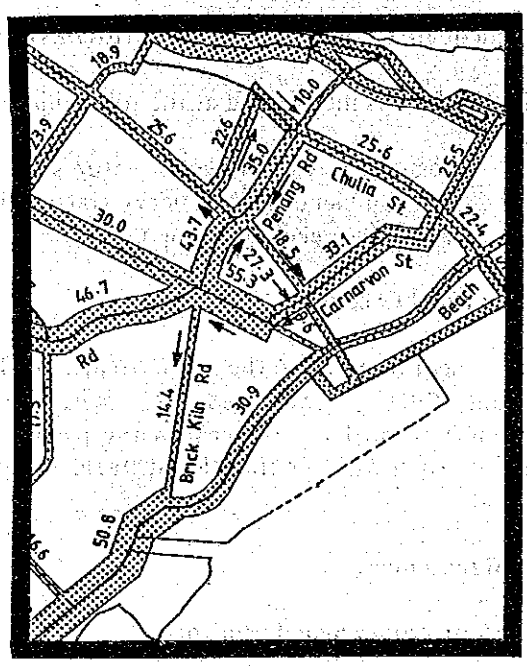


Figure 2.3.9 : Traffic Circulation System With 12-Hour Volume In the periphery of KOMTAR

C. Congestion

1. Deficient Traffic Capacity of Roads and Intersections

Bottleneck congestions are caused by deficient traffic capacity of roads and intersections as mentioned below :

(1) Narrowness of roadway.

(2) Inadequate provision of intersection approach space to accommodate the traffic demands.

(3) Improper signal phasing and timing at signalized intersections.

(4) Roundabouts with small island.

(5) Irregularity of intersection type.

2. Various Causes of Congestion

Congestion is caused mainly by inadequate provision of intersection approach facilities, and is also augmented by various adverse conditions as mentioned below :

(1) Bus stoppages (especially on heavy volume roadways) which disrupt traffic flow

(2) Parked cars and cars in the act of parking

(3) On-street waiting cars

(4) Loading and unloading of merchandise by commercial vehicles on busy roadways

(5) Pedestrian movement on carriageway

(6) Road-side activities

(7) Trishaw and hawker movements on carriageway

(8) Disrespect for traffic-control devices by drivers

3. Congestion in the Central Area

Heavy congestion seems to be concentrated in the Central Area particularly at the following roadways :

(1) Perak Road (between Anson Road and Sungai Pinang Road)

(2) Bridge Street and Jelutong Road

(3) Roadways in the proximity of KOMTAR

(4) Carnarvon Street and Pitt Street

(5) Dato Keramat Road (between Magazine Circus and Perak Road)

(6) Anson Road

(7) Burma Road

D. Accident

1. High Accident Rates Recorded in George Town

Table 2.3.2 compares the accident data in George Town, Kuala Lumpur and Japan.

Fatality accident rates as well as injury accident rates in George Town are conspicuously higher than those in Kuala Lumpur and Japan.

Table 2.3.2 : Comparison of Accident Data

	George Town	Kuala Lumpur	Japan
Fatal accident per 100,000 population	41.6	8.1	7.6
*Injury accident per 100,000 population	1,009.6	121.9	527.5
Fatal accident per 10,000 vehicles	6.9	5.2	1.6
*Injury accident per 10,000 vehicles	167.5	78.4	107.1

* Reference only, because the definition of injury may be different in data sources.

2. Frequent Accidents between Car and Motorcycle

Car/motorcycle collisions are prominent in terms of number and severity. Car/motorcycle collisions account for a high percentage in the number of fatal accidents, injury accidents and the total number of accidents at 17.0%, 41.7% and 30.7% respectively.

3. High Accident Exposure Rate of Pedestrians

The accident exposure rate of pedestrians is quite high in George Town. The result shows that the accident exposure rate of pedestrians is estimated to be 175 per 100,000 persons and the pedestrian fatality rate at 12.8 per 100,000 persons in George Town, while in Japan, these figures are 70 and 2.1 respectively.

E. Others

1. Insufficient Traffic Education

Most motorcyclists ride their vehicles recklessly on the streets. This lack of discipline has also been observed among car and bus drivers.

Drivers, in general, are not exposed to proper education and discipline. The concept of 'right of way' does not seem to exist or seems to be ignored in most cases. Dangerous lane-changing, overtaking into the opposite side of the street as well as violating signal are common phenomena in Penang Island.

2. High Usage of Motorcycles

Traffic in Penang Island is made up mostly of private cars and motorcycles and public buses. Although motorcycles are convenient for many drivers, they create the following traffic problems in Penang Island.

(1) Many traffic accidents caused by collision between motorcycles and cars result in death or injury for motorcyclists.

(2) Disruption of walking routes by disorderly parking.

(3) Decline in environmental level in residential areas due to the presence of motorcycles.

2.4 Public Transport

2.4.1 Bus Transport

Besides the stage bus, bus transport in the Study Area is also provided by factory and school bus. Factory buses are either owned by the factory or contracted by the factory to serve mainly the workers in the factories located in the Free Trade Zone. About 90% of the factory workers are known to commute by factory buses. On the other hand the school bus is used for sending pupils only to school.

Table 2.4.1 shows the comparative figures on bus transport operations in the Study Area. The total number of factory and school buses combined together in 1986 was three times more than the total number of stage buses in operation. Moreover, in terms of trips per day and vehicle kilometer runned per day, factory and school buses have a combined share of nearly 50% of the total. Thus factory and school buses have contributed greatly to mass transportation but at the same time became a cause for the inefficient usage of stage buses. The situation is worsen by some factory and school buses picking up other passengers not included in their contracts and the existence of illegal taxi operations.

Henceforth, the reaffirmation of the respective roles of stage, factory and school buses and the rationalization of bus route network are important issues in the bus transport improvement plan.

Table 2.4.1 : Bus Transport Operation in Study Area, 1986

	Stage Bus	Factory Bus	School Bus	Total
No. of Buses	160* (24%)	200** (30%)	314** (46%)	674 (100%)
Average Bus Capacity	70	40	25	–
Average No. of Trips/Vehicle	18.3	4.5	4.3	–
Average No. of Trips/Day	2,920 (57%)	900 (17%)	1,350 (26%)	5,170 (100%)
Vehicle Kilometer/Day	35,000 (51%)	12,000 (18%)	21,000 (31%)	68,000 (100%)
Average Kilometer/Trip	12	13	15	13

* Study Team's estimated fleet in operation for Study Area only. Total fleet owned by bus companies is 222 buses.

** Study Team's estimation from RIMV records.

A. Bus Companies Operating on Penang Island

In Penang Island, there are five bus companies, that is the City Council Bus and four privately owned bus companies (Penang Yellow Bus, Hin Bus, Lim Seng Seng Bus and Sri Negara Bus).

The five bus companies provide services for the different areas as follows:

(1) City Council buses serve the city area of George Town

(2) Penang Yellow buses serve the southern and western parts of the Island

(3) Hin buses serve the northern part of the Island

(4) Lim Seng Seng buses operate between George Town and Ayer Itam

(5) Sri Negara Buses serve the northern part of George Town

Most of the buses operate radially from the centre of George Town. The bus service coverage by the five companies is shown in Figure 2.4.1. It can be seen that the bus service covers almost all the populated areas in Penang Island.

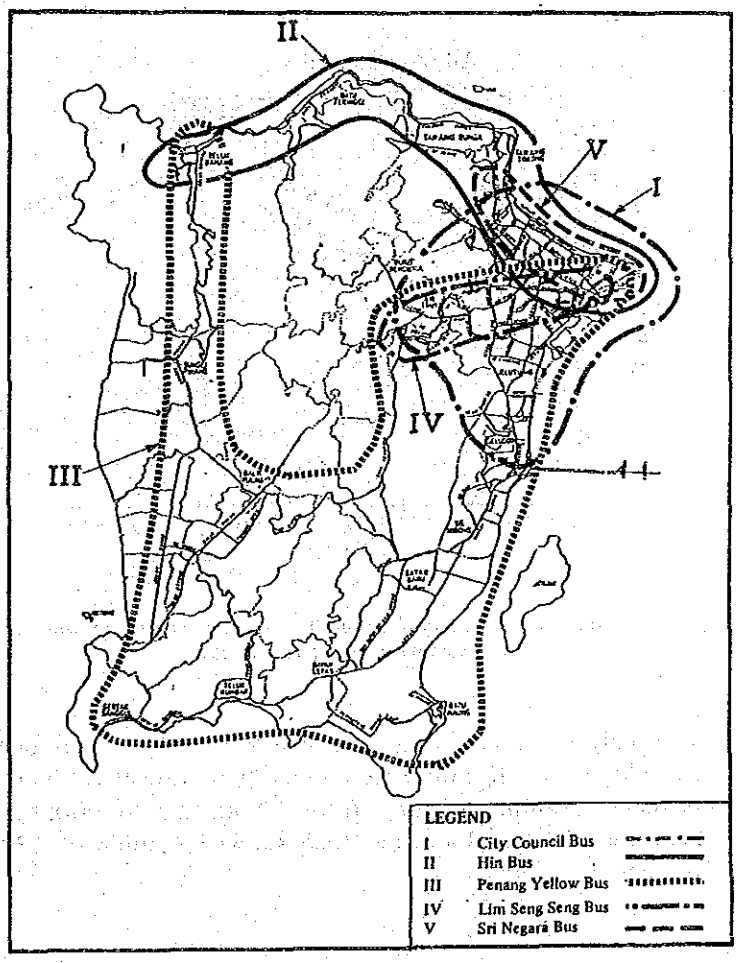


Figure 2.4.1 : Bus Service Coverage In Penang Island

B. Existing Stage Bus Transport System

1. Bus Passengers Volume and Mode Share

Figure 2.4.2 illustrates the trend in annual passenger number carried by stage bus companies in the Study Area between 1975 and 1985 and the growth of motorization in Penang State. During 1975 to 1980, the number of bus passengers remained steady at 65 million but it declined by 7.2% annually since 1980 while motorization advanced steadily at 9.7% per annum. By 1985, the number of passengers carried by all the stage bus companies had been reduced to 60% of the amount in 1975. In particular, over a decade the number of passengers carried by buses serving George Town had been reduced drastically to merely half the volume in 1975.

The passenger share by transportation mode on the screen line in 1985 revealed the share of buses at 23%, of which the stage bus constituted only 13.4%. Cars and motorcycles transported 40% and 37% of the total passengers respectively. Considering the role of buses as a mass transportation means, there is plenty of room for improving the mode share of buses.

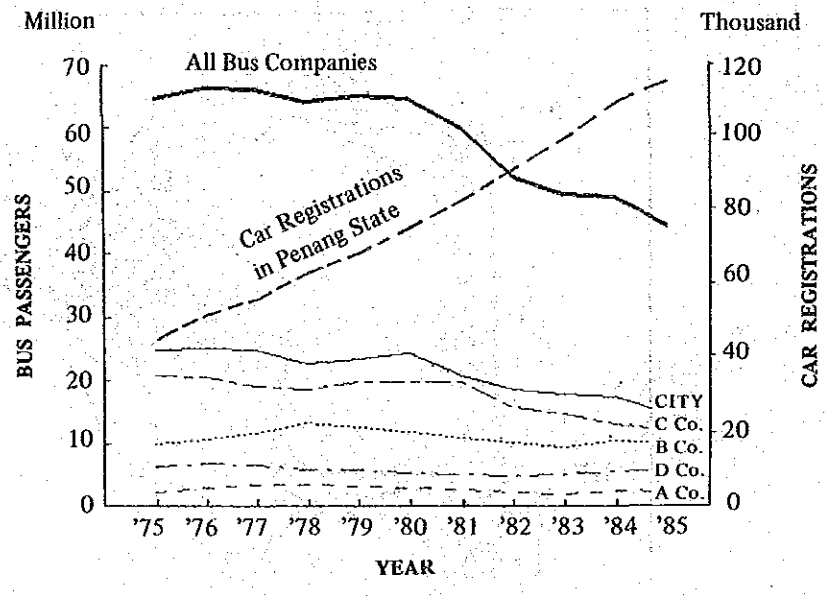


Figure 2.4.2 : Annual Trend of Stage Bus Passengers and Growth of Motorization (1975–1985)

The daily passenger volume on major bus routes is shown in Figure 2.4.3. Bus along Dato Keramat Road and Ayer Itam Road had the highest daily passenger volume ranging from 12,000 to 30,000. The sections on Jelutong Road and Burma Road showed volume of 13,000 and 10,000 respectively.

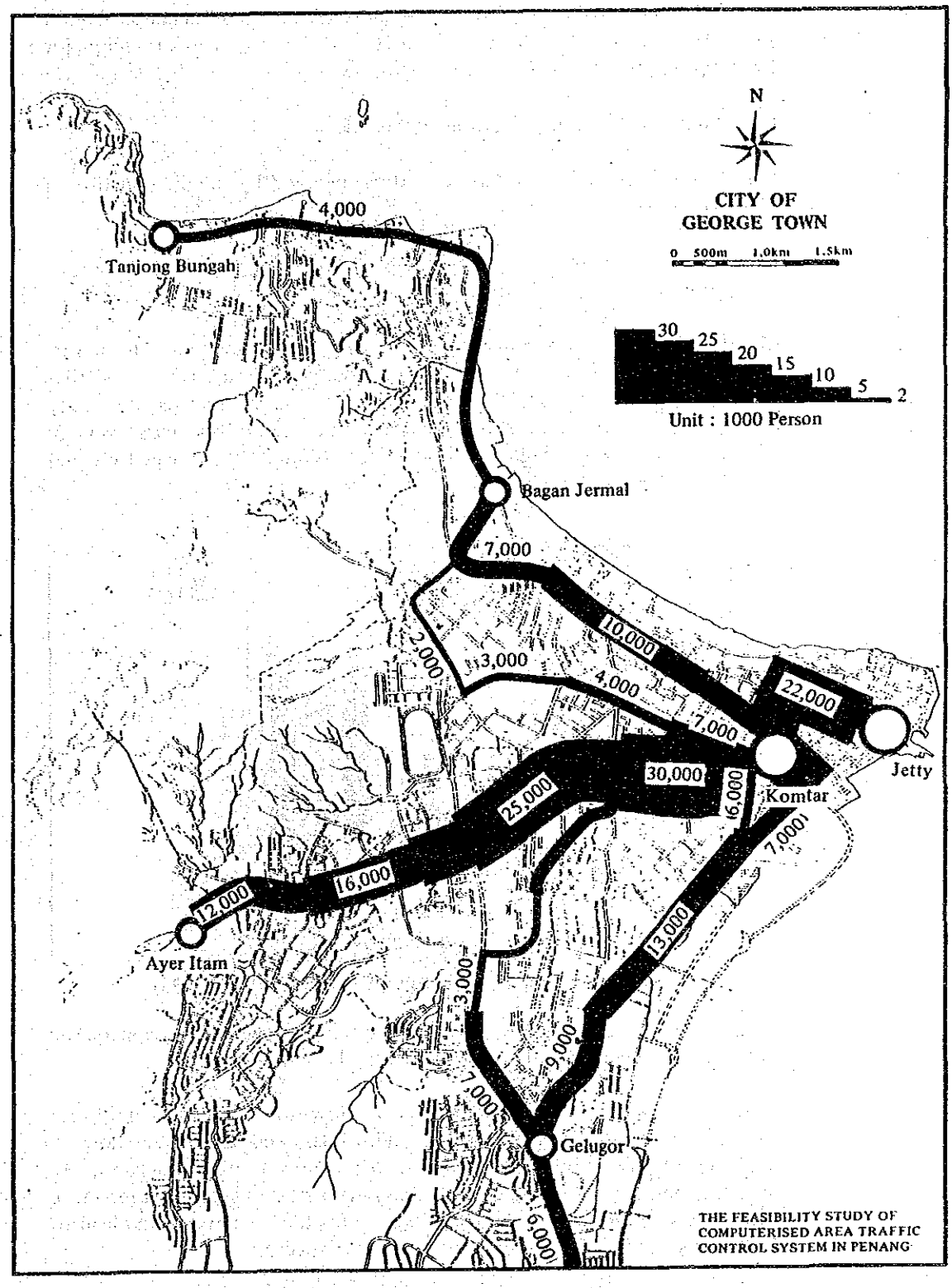


Figure 2.4.3 : Daily Bus Passenger Volume on Major Bus Routes, 1985

The following attributes of stage bus passengers were ellucidated from a Bus Passenger Interview Survey conducted at the bus terminals and major bus stops in the Central Area of George Town.

(1) About 50% of bus passengers were male,

(2) Majority were in their twenties; those below 30 years old constituted about 60%,

(3) Most passengers belonged to the clerical, factory worker, student or housewife categories of occupation,

(4) In terms of trip purpose, 'to work', 'business' and 'to home' constituted about 70% of all respondents. Compared to a similar survey conducted in 1979, the share of these trip purposes was only 50%. Figure 2.4.4 shows the trip purpose of bus passengers in 1979 and 1986. This reflected a decrease in bus patronage for other trip purposes.

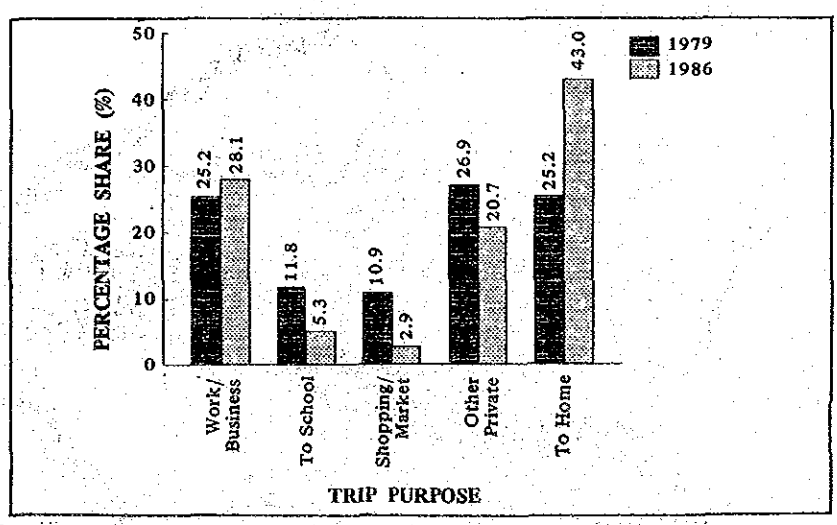


Figure 2.4.4 : Trip Purpose of Bus Passenger (1979 and 1986)

From the above observations on the attributes of stage bus passengers, the following problems and planning issues may be summarised.

Together with the growth of motorization, downtown bus users and those above 30 years old belonging to the middle-class and above had shown a tendency to give up bus ridership. The existing bus users belonged mainly to the young worker group and the trip purpose by bus had become more limited to commuting and return to home. Such a tendency could lead to further decline in bus passenger volume in the future.

Therefore, to increase bus passenger volume, it would be necessary to attract a wider spectrum of bus users from all age groups and to improve bus services to cater for more categories of trip purposes. This is an important planning issue.

2. Bus Service

a. Coverage (convenience)

Presently, there is supposedly a total of about three thousand (3,000) bus trips per day running on thirty-four (34) routes in the Study Area. On the whole, most part of the Study Area is covered by the existing bus routes. However, from the standpoint of trip frequency, most of the bus routes are concentrated along the three (3) radial roads – Burma Road, Dato Keramat Road and Jelutong Road. On other roads, there are fewer routes and lower frequency.

The bus service coverage area had been calculated as the area within a 250 meters radius from a bus-stop when the expected walking time is 5 minutes. However, a Bus Passenger Interview Survey conducted by the Study Team found that 73% of the respondents required access time of more than 5 minutes on foot. Figure 2.4.5 shows the time taken by bus commuters to walk to bus terminals/stops. Therefore the accessibility of bus-stops cannot be said to be really good.

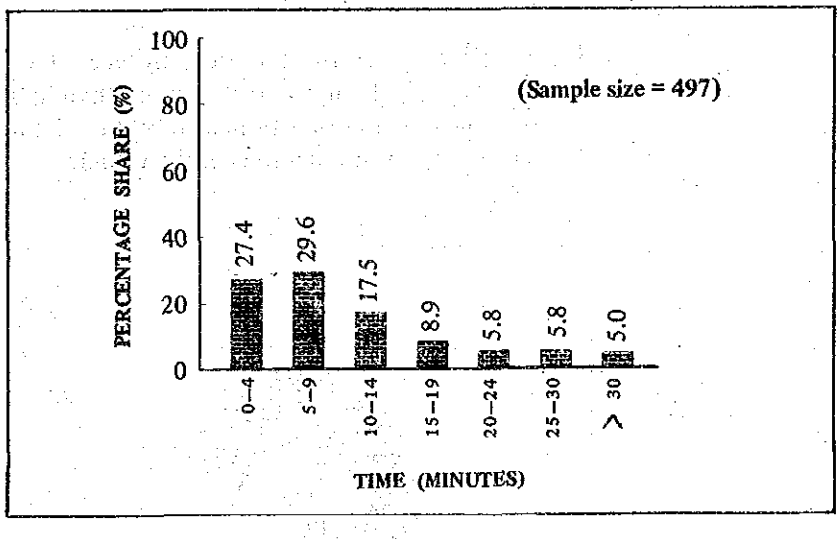


Figure 2.4.5 : Time Taken by Bus Commuters to Walk to Bus Terminals/Stops

Furthermore, the survey also revealed that more than 50% of the respondents had to wait for longer than 20 minutes at bus-stops. Figure 2.4.6 illustrates the waiting time for bus service.

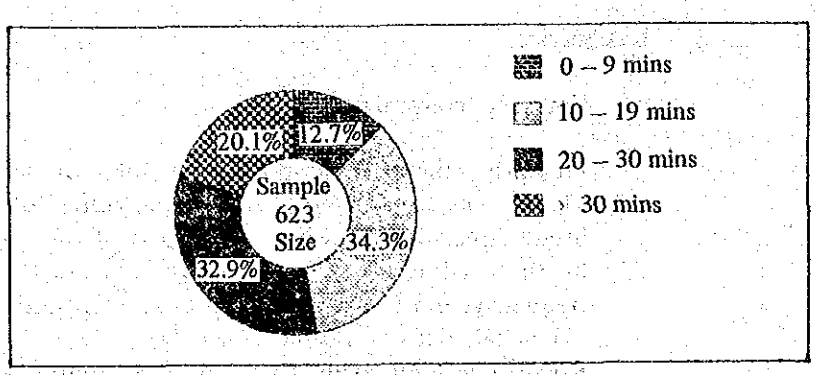


Figure 2.4.6 : Waiting Time for Bus Service

Bus speed inside the Central Area and along Dato Keramat Road and Jelutong Road is below 20 km/hr. In the long term, as traffic demand increases on Dato Keramat Road further traffic congestion can be expected. At such a point in time, it would be necessary to consider the introduction of bus-lane on this road.

b. Comfort

Figure 2.4.7 shows the bus fleet by age. Of the present stage bus fleet of 222 (as of August 1986), more than half are over 8 years old. There is also no air-conditioned stage bus. Thus, there is much room for improvement of amenities in the vehicle.

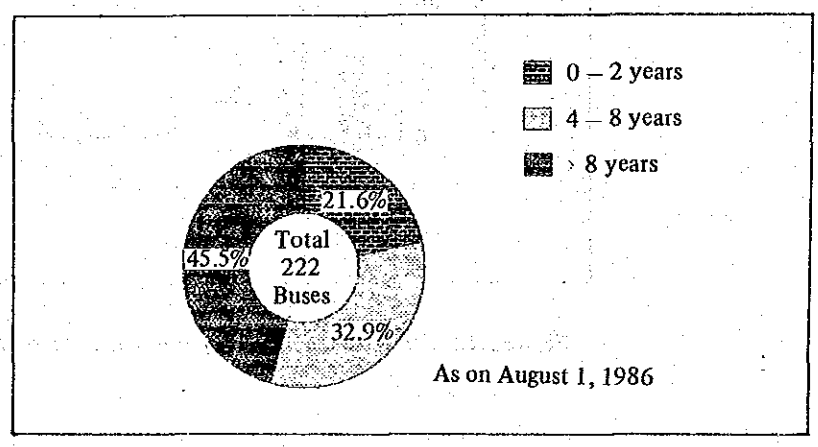


Figure 2.4.7 : Bus Fleet by Age

There are two main bus terminals and one bus interchange in the CBD. The Komtar Interchange had been built as part of the KOMTAR project while the existing bus terminals are of the open space type. The facilities at these terminals and interchange are inadequate from the functional and amenity viewpoints.

Besides these, bus-stop facilities need to be improved.

c. Dependability

Dependability of bus service is determined by the ability of the buses to depart at the scheduled time and to arrive at the destination point by the expected time. The problem here is, firstly, at the bus-stop and terminals, there is no timetable. It is not possible to confirm the arrival or departure time. Secondly, from the Study Team's observations, the actual frequency of bus service was supposedly about 75% of the scheduled frequency of bus trips. Figure 2.4.8 shows the hourly fluctuation of actual and scheduled daily bus trips (City Council Bus).

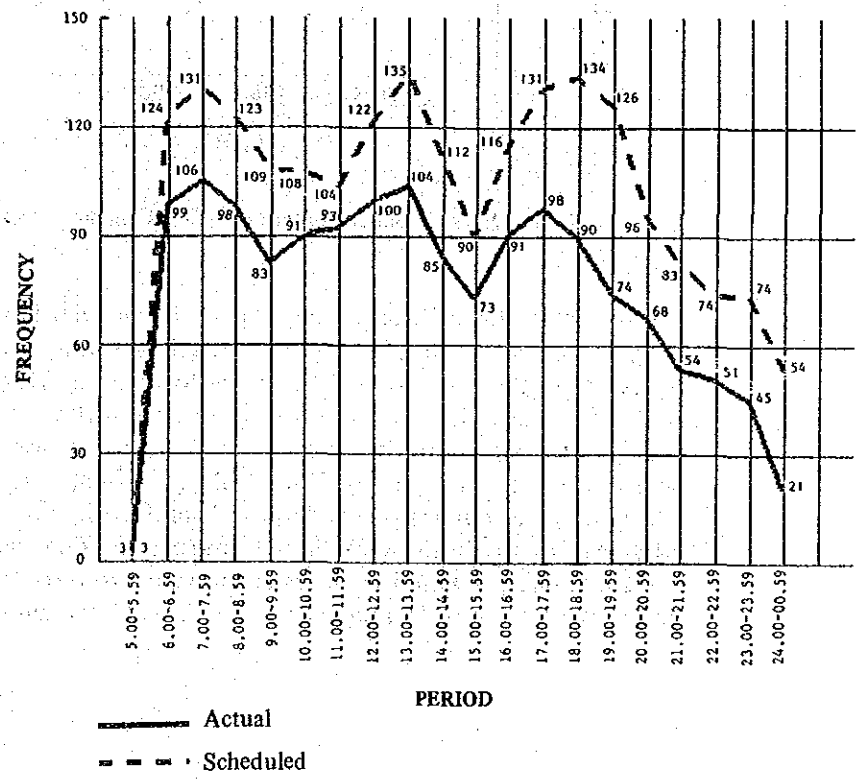


Figure 2.4.8 : Hourly Fluctuation of Actual and Scheduled Daily Bus Trips (City Council Bus)

3. Financial Situation and Efficiency of Bus Companies

Figure 2.4.9 illustrates the financial situation of the five (5) bus companies from 1983 to 1985. Despite an increase in bus fare implemented in 1984, City Council Bus Company still remained in bad financial situation although other bus companies reported increases in revenue. However, in more recent years, due to the drastic drop in passenger volume, the revenue of all companies had been observed to decline.

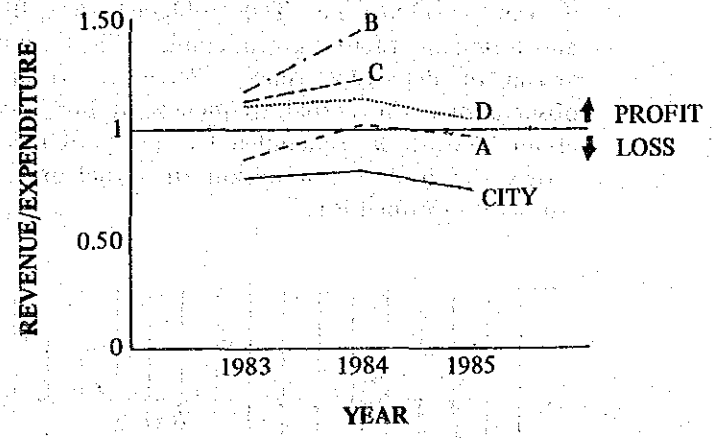
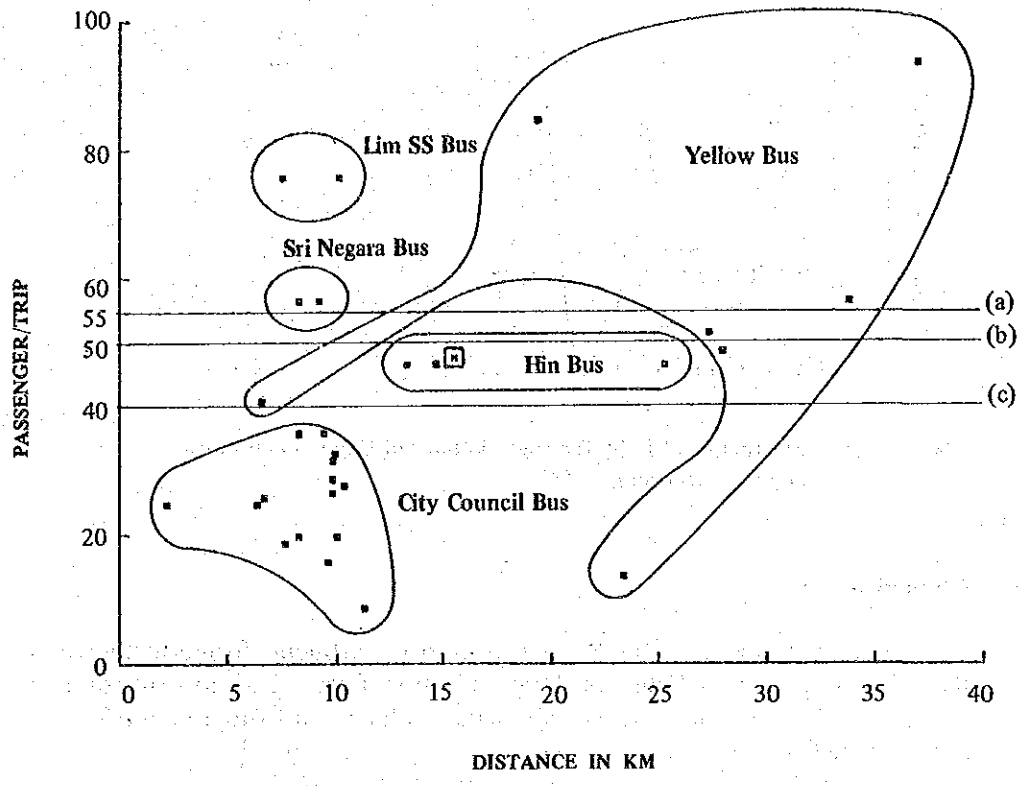


Figure 2.4.9 : Financial Situation of Bus Company (1983–1985)

Figure 2.4.10 depicts the passenger per trip on each bus route. From an analysis of passenger per trip by each bus route, it is observed that ridership on the City Council buses was low and inefficient. These routes are competiting with each other for most part of the journey or are routes which detoured from the main roads to provide social service to low demand area or route such as No. 13 (Bagan Jermal – Jelutong) where the OD volume is not especially large. Therefore in order to increase the efficiency of the bus operation and improve the financial situation of the bus companies, it would be necessary to resort to rerouting of the existing bus network to provide a balance in the demand and supply.



Notes : a) Average for Lim Seng Seng and Sri Negara
b) Average for Yellow Bus
c) Average for City and Hin Bus

Figure 2.4.10 : Passenger Per Trip On Each Bus Route

Moreover, due to traffic congestion, bus speed had dropped and it was not possible to achieve punctuality which made it difficult to plan a more efficient bus schedule. In this context, it would be necessary to rationalize the bus companies to provide a more efficient service from the viewpoint of the economics of operation. This is an important problem which must be studied further.

Furthermore, one of the reasons for the deterioration of the bus operation's efficiency is due to the drastic fluctuation of passengers during peak and off-peak hours. Figure 2.4.11 shows the comparison of daily passenger volume fluctuation for City Council buses on one of its main route in 1975 and 1986. Passenger volume which were concentrated during peak hours only had become even more pronounced in 1986. Such a situation is related to the fact that most bus users belonged to the same age-group and most trips were limited to commuting and return to home.