4.2.3 ATC System Perspective Plan

The future comprehensive ATC system is to be geared towards traffic surveillance and/or control, covering the Greater Metropolitan Areas of George Town, Bayan Lepas, the Coastal Road, the Penang Bridge and further on Butterworth and Bukit Mertajam, even if traffic in these areas is managed and controlled by different traffic authorities. Of course, problems that involve overlapping of the concerns of the various authorities will occur when the ATC system is implemented and will have to be settled through cooperation and, sometimes, compromise.

It is especially recommended that traffic flow between George Town and the Coastal Road, which are closely interrelated, be managed and controlled by one traffic control authority with one particular policy and method. If this is not possible, then at least the various authorities should exchange traffic information with each other.

The area coverage of the ATC System Perspective Plan by stages is illustrated in Figure 4.3.

The period for implementation of each ATC system will depend on road and traffic conditions as well as the degree of necessity. The conceptual scheme for the introduction of the ATC System in each sub-area is:

Stage I	:	Central Area of George Town
Stages II & III	:	George Town
Stage IV	:	Bayan Lepas
Future Stages	:	Coastal Road and Penang Bridge as well as Butterworth and Bukit Mertajam

Stage I has been implemented by the MPPP. Stages II and III which will cover the entire city of George Town are to be carried out by the MPPP in the future. Similarly, Stage IV which will cover Bayan Lepas will be implemented by the MPPP in the future.

The feasibility study of the ATC system for Stages II, III and IV is the objective of this Study.

In future stages, the ATC system for Penang Island will be connected to an Expressway Surveillance and Control System for the Coastal Road and Penang Bridge. Alternatively the Penang Island System may incorporate the Coastal Road and Penang Bridge Expressway Surveillance and Control System. In addition, an ATC system for Butterworth and/or Bukit Mertajam will be connected to the ATC system of Penang Island to facilitate exchange of road and traffic-related information. It is expected that Majlis Perbandaran Seberang Perai (MPSP) will introduce an ATC system to cope with traffic pressure in the areas of Butterworth and Bukit Mertajam.

Thus, the ATC system shall be capable of accommodating other systems such as the expressway surveillance and control system for Penang Bridge and Coastal Road, as well as Butterworth and Bukit Mertajam without major modification to the ATC System for Penang Island.

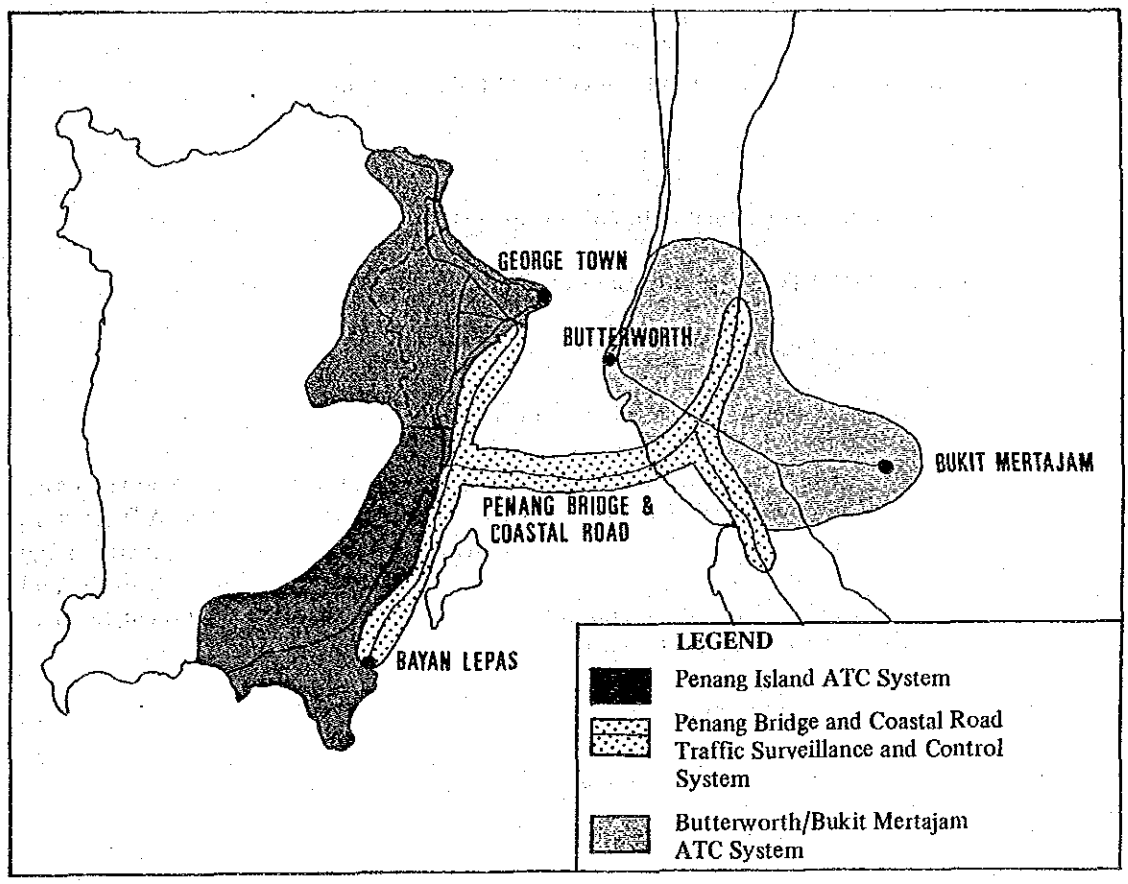


Figure 4.3 : ATC System Perspective Plan

4.2.4 ATC System Expansion Plan

The following ATC System Expansion Plan is proposed as a measure to further increase the effect of the Stage I ATC System which began operation from April, 1987 and to ensure smooth traffic flow and at the same time safe pedestrian crossings.

The components of this plan are:

(1) Expansion of traffic signal control system

(2) Expansion of closed circuit television (CCTV) system

(3) Introduction of driver information system

(4) Promotion of statistical data collection system

A. Conceptual ATC System Expansion Plan

1. Traffic Signal Control System

a. Concepts of Traffic Signal Control Plan

The area-wide traffic signal control system is the backbone of this comprehensive traffic control system in Penang. The ATC system aims at increasing traffic control by centralizing the traffic signal controllers, systematizing necessary functions comprehensively and also operating traffic control with high reliability. Typical features of the ATC system are:

(1) On-line control

(2) Computer control

(3) Fail-safe operation

b. Traffic Signal Control Method of the ATC System

The ATC System provides the following traffic signal control method.

1) Same signal cycle time operation in sub-area

Under computer control, all traffic signals always operate with same cycle time within a sub-area that has several signalized intersections.

2) Preparation of Control Parameter

A control parameter is a combination of a cycle time, split and offset. In the central computer, these control parameters are prepared for each sub-area.

3) Control Parameter Selection

There are two ways to select the most suitable control parameter from prepared ones.

(1) Automatic selection

(2) Time-of-Day selection

4) Vehicle-actuated Control

At a signalized intersection, a vehicle-actuated control, which extends the end of a green time in every cycle by arrival of vehicles, is more effective in giving a better split time than the fixed time method.

5) Status Change

The status change control method is to change the sequential display pattern of signal lights at a intersection. For example, the flashing operation at midnight and the cancellation of the special step (the step dedicated to right turn) of the sequential display according to the traffic condition are to reduce waste time.

6) Manual Control

In anticipation of special circumstances like a traffic accident, manual control by a policeman is provided.

These control functions have already been provided in Stage I, although on a small scale. These functions should remain. Other additional functions may not be necessary for the expansion of the traffic signal control system. Thus, the expansion plan is discussed based on this consideration. However, it may be necessary to modify existing methods or introduce new ones to this system in the future, although it is at present the latest one and is highly reliable compared to others.

2. Closed Circuit Television (CCTV) System

Closed Circuit Television (CCTV) has become a major part of computerised traffic control system for urban streets in cities. Closed-circuit television enables operators in a central control room to view traffic conditions at locations where cameras are placed.

The hardware structure for the future system is the same as that of the Stage I system except that the number of cameras and TVs monitor will be increased.

3. Driver Information System

Driver Information System is a man-machine system, which obtains traffic related information from various sources and conveys the information to drivers on the road as quickly and as accurately as possible, so that the drivers can either avoid traffic congestion or follow the traffic regulations being enforced by the traffic management authority.

a. Gathering Traffic-Related Information System

It is important to gather traffic-related information such as traffic congestion degree and its locations, accident locations, road maintenance locations, etc.. Based on this information, comprehensive traffic control is performed.

Several ways to obtain this information can be considered: traffic detector, CCTV camera, police mobile radio, telephone, etc.. The main ways in the ATC system in Penang are through traffic detectors and CCTV cameras.

In Stage II, the existing display map will be modified so that it can also display congestion degree and queue lengths at additional critical intersections. In Stages III and IV, either a new display map is added to the existing map on the wall of the control room, or the existing map will be replaced by a new display map. Another method of display – colour graphics terminals – will be considered to display queue conditions at critical intersections and other traffic-related information obtained through the main computer.

b. Conveying Traffic-Related Information To Drivers

To convey traffic-related information to drivers, it is practical and useful for the future Penang system to adopt the use of changeable message signboard, commercial radio and public address system.

4. Statistical Data Collection System

Main functions of the statistical data collection system are to record traffic data, control data and error data of the ATC system, and also to print appropriate reports automatically.

B. Conceptual Hardware Structure Plan

Four (4) major systems are provided for the traffic control in Penang Island, namely signal control system, driver information system, CCTV system and statistical data collection system. Furthermore, the system will accommodate the expressway surveillance and control system and the traffic control system in Butterworth and Bukit Mertajam area.

The signal control system is mainly composed of a host computer and three (3) micro-computers i.e. front-end processors (FEP's) : two FEP's for George Town and one FEP for Bayan Lepas. The FEP has a capacity of controlling sixty-four (64) traffic signals and one hundred (100) vehicle detectors. All FEP's are connected to the host computer via communication lines.

In addition, a micro-computer for the driver information system will be necessary.

Figure 4.4 depicts the main hardware structure plan of the ATC System Expansion Plan.

C. **Proposed ATC System Staging Plan**

Under the ATC System Expansion Plan, there will be one hundred and forty-nine (149) signalised intersections under computerised control including the sixteen (16) computerised intersections in Stage I. There will be a total of sixteen (16) CCTV cameras under the ATC System Expansion Plan including the two (2) CCTV cameras in Stage I. Installation of seven (7) changeable message signboards will be carried out under the Expansion Plan.

Figure 4.5 illustrates the ATC System Staging Plan and Table 4.1 summarises the number of equipment units in each stage of the Expansion Plan.

Further details of the staging plan of traffic signal control system is illustrated in Table 4.2 whereas those of closed circuit television system and driver information system are shown in Table 4.3.

Figure 4.6 depicts the signal location in each stage in George Town and Bayan Lepas, whereas the CCTV camera and changeable message signboard locations are illustrated in Figures 4.7 and 4.8 respectively.

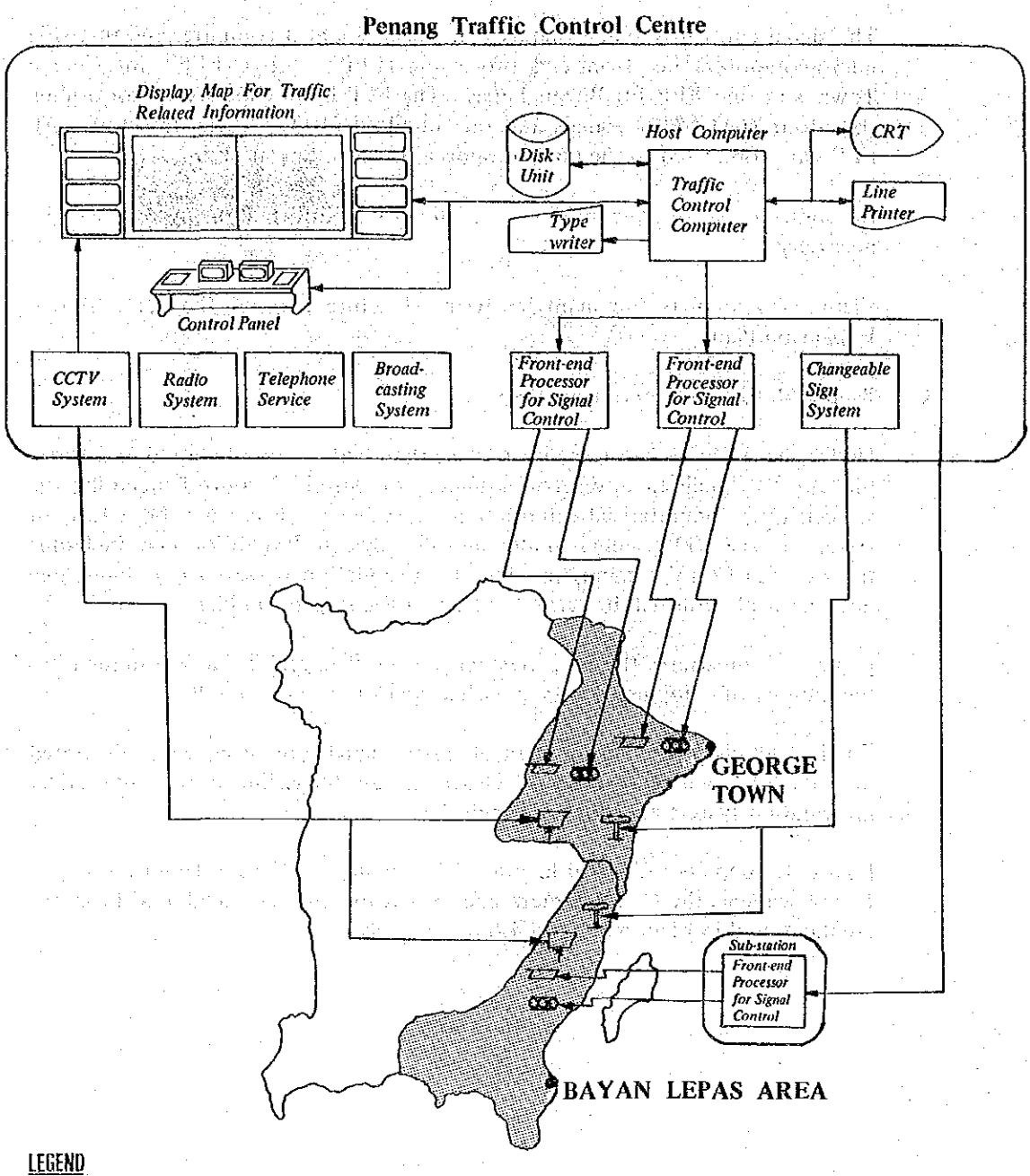


Figure 4.4 : Main Hardware Structure Plan

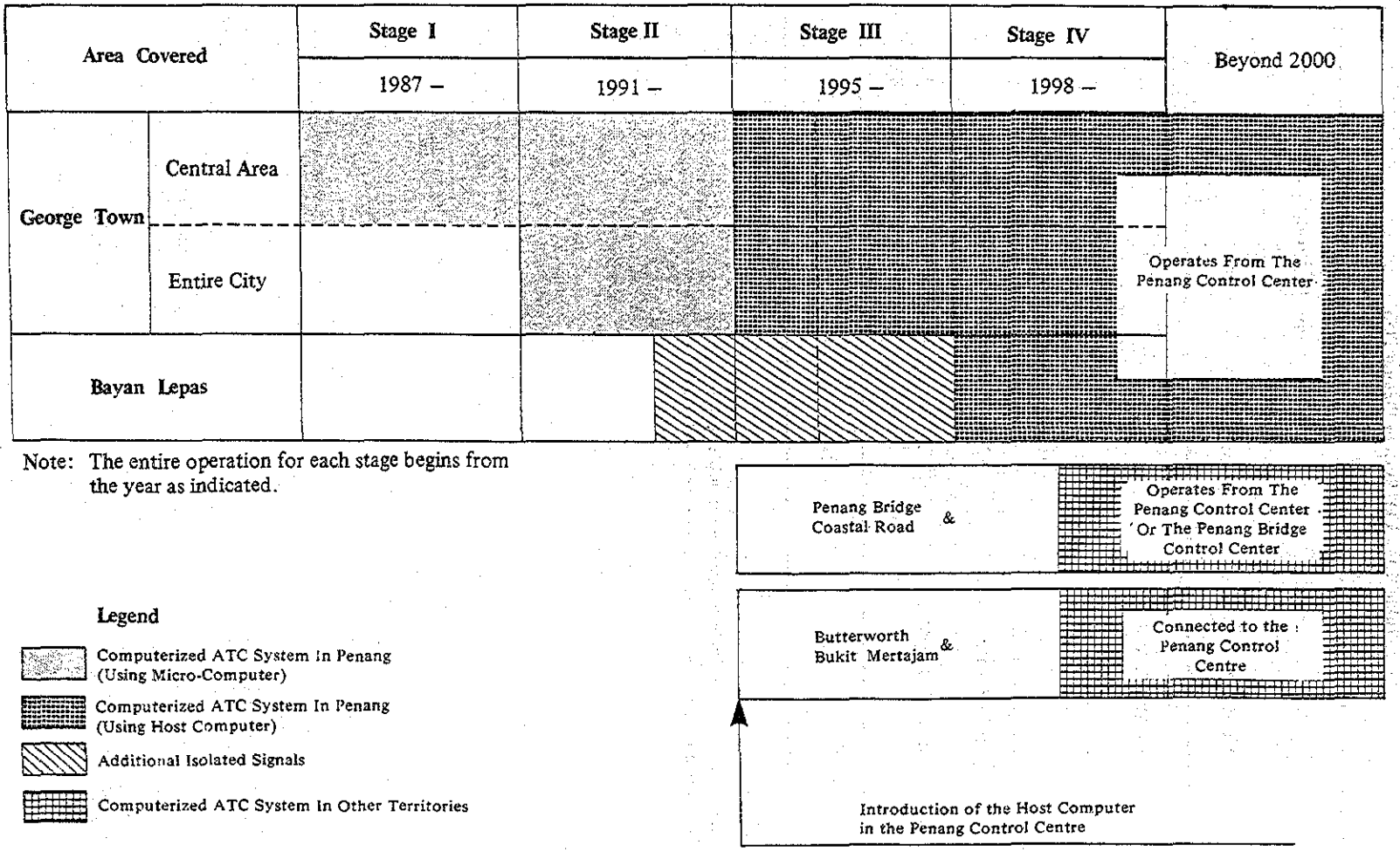


Figure 4.5 : ATC System Staging Plan

Table 4.1 : ATC System Staging Plan

	Coverage Area	No. of Equipment		
		Signal set	CCTV	Sign Boards
Stage I	Central Area	16	2	0
Stage II	George Town	44 5*	8	0
Stage III	George Town and its suburbs	59	6	2
Stage IV	Bayan Lepas	25	2	2 3**
Total	Study Area	149	16	7

Note : Stage I is already in operation

* Five (5) sets of signals will be installed in Bayan Lepas area.

** Three (3) changeable message signboards will be installed in George Town.

Table 4.2 : Staging Plan of Traffic Signal Control System

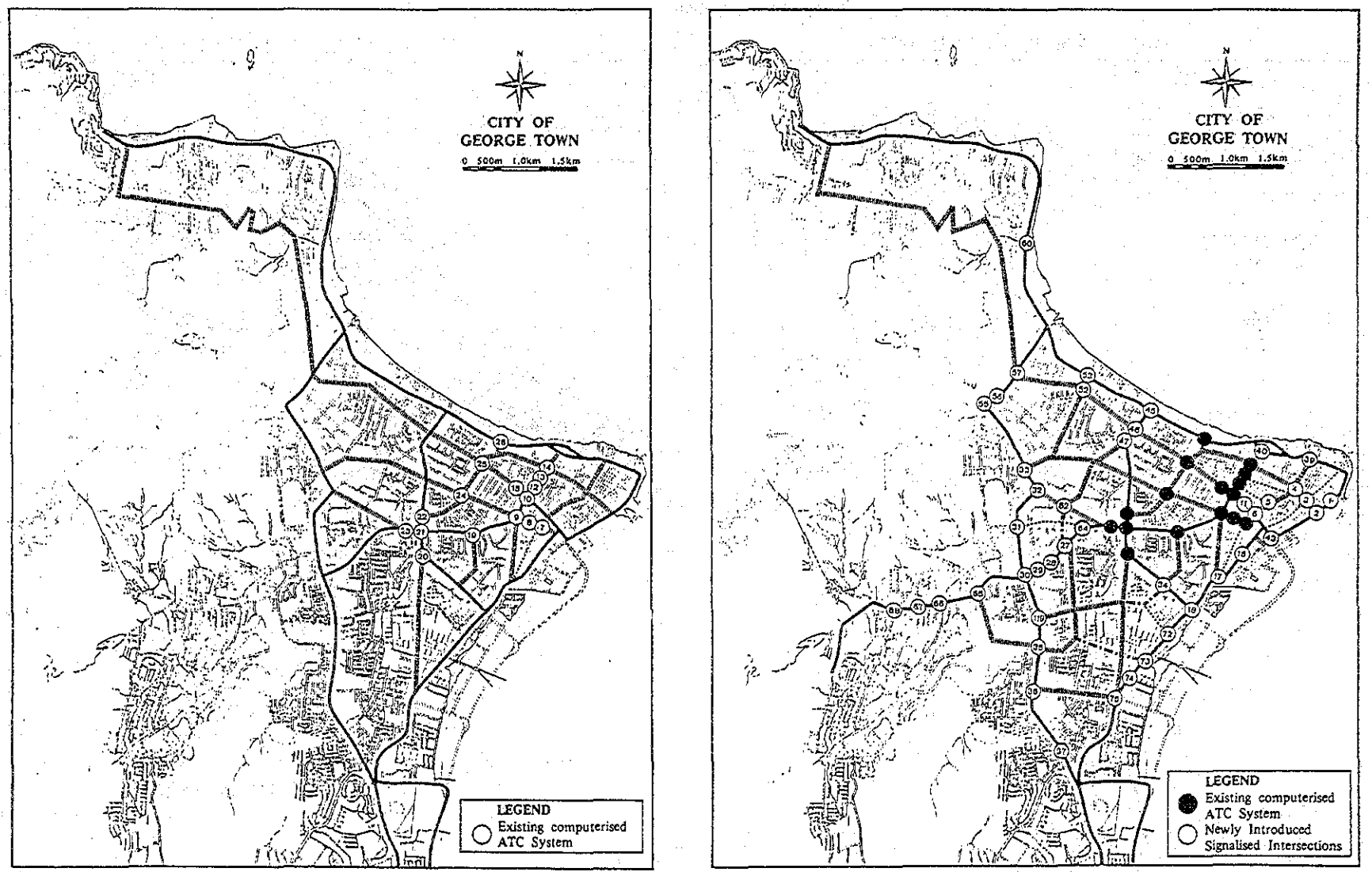
AREA COVERED		Stage I	Stage II	Stage III	Stage IV
		1987 –	1991 –	1995 –	1998 –
George Town	Central Area	Installation of computerized signals at 16 intersections	44 intersections to be controlled by computerized signals If other intersections required to be signalized in Stage III, micro-type of local controllers available to be connected to the computer will be adopted	29 intersections of high priority to be controlled by computerized signals 30 intersections of low priority to be controlled by computerized signals	Signalization requirements will be examined along the course of the project and necessary actions will be taken
	Entire City				
Bayan Lepas			5 intersections to be controlled by isolated signals, using the micro-type of local controller		Total 30 intersections to be controlled by computerized signals including 5 intersections installed in Stage II
Central Equipment		ATC Micro-Computer (Front-end processor) is introduced in the Control Centre		A host computer and a Front-End processor to be introduced in the Control Centre	A sub-station provided with a Front-End processor to be constructed in Bayan Lepas area
Foreseeable Events		Computerized ATC System in operation since April 1987		Opening of North Coastal Road	

Note : The entire operation for each stage begins from the year as indicated.

Table 4.3 : Staging Plan of Closed Circuit Television System and Driver Information System

AREA COVERED	Stage I	Stage II	Stage III	Stage IV
	1987 –	1991 –	1995 –	1998 –
George Town	2 cameras 2 monitor TV's	8 cameras 8 monitor TV's	6 cameras 6 monitor TV's 2 Changeable Message Sign-boards	3 Changeable Message Sign-boards Necessary actions will be taken
Bayan Lepas				2 cameras 2 monitor TV's 2 Changeable Message Sign-boards

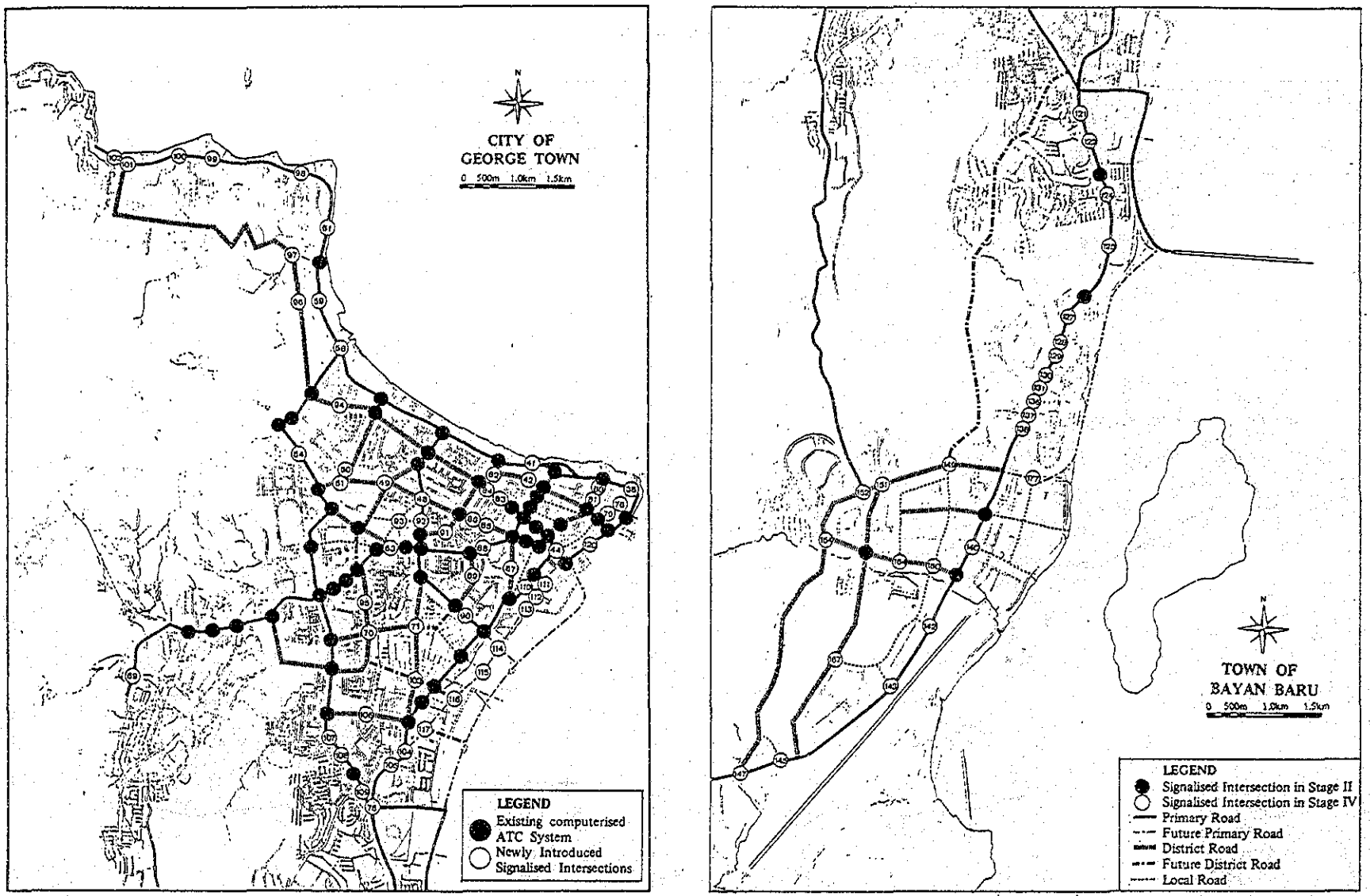
Note : The entire operation for each stage begins from the year as indicated.



Stage I in George Town

Stage II in George Town

Figure 4.6 (1) : Signal Locations in each Stage in George Town and Bayan Lepas



Stage III in George Town

Stage II & IV in Bayan Lepas

Figure 4.6 (2) : Signal Locations in each Stage in George Town and Bayan Lepas

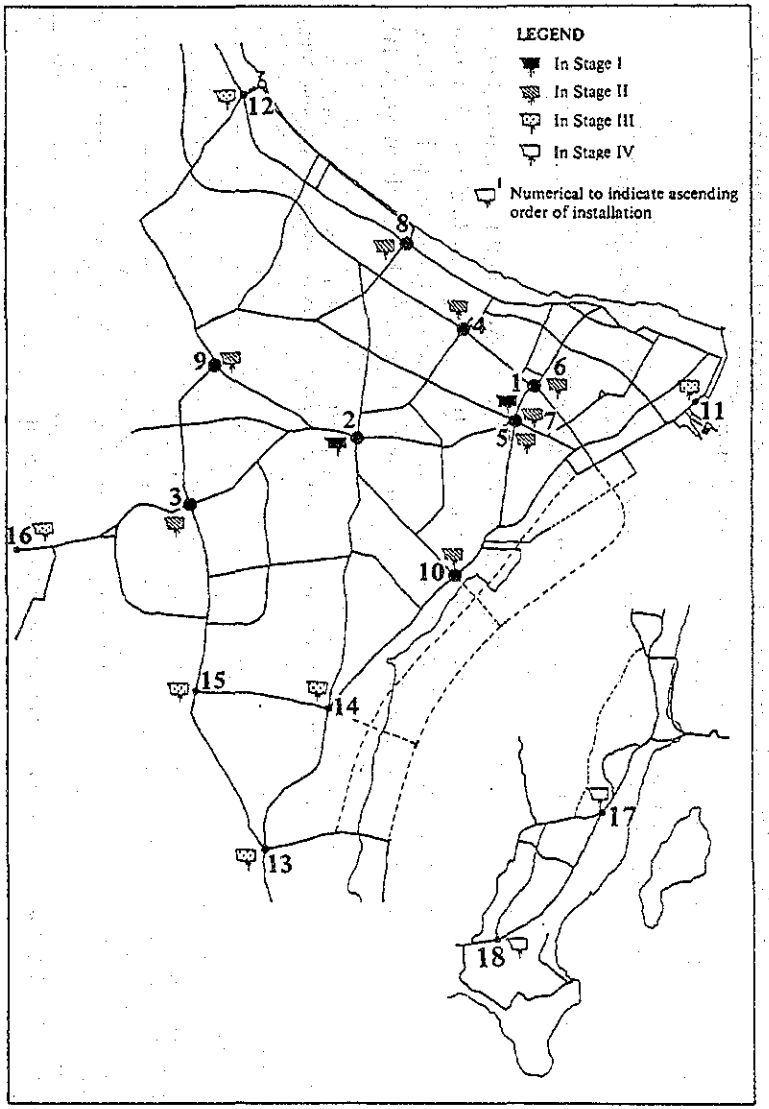


Figure 4.7 : CCTV Camera Locations

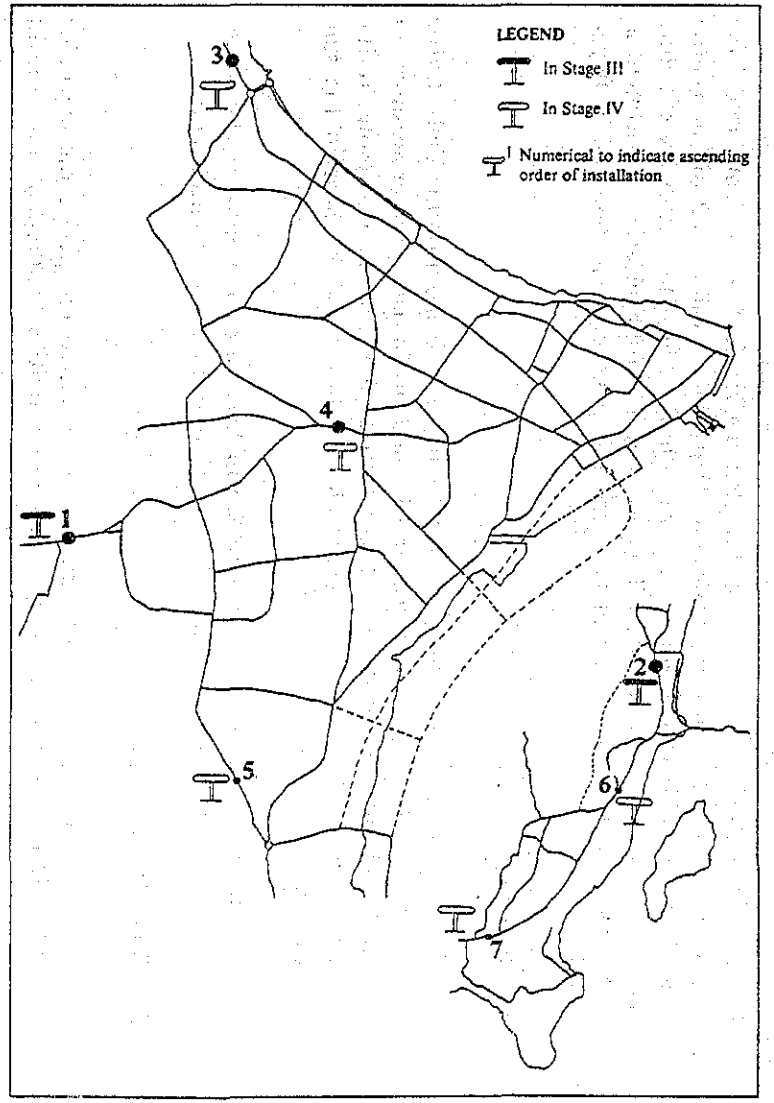


Figure 4.8 : Changeable Message Sign Board Locations

4.2.5 Management of Traffic Control Centre

The control centre which can be called the Penang Traffic Control Centre under the jurisdiction of the Director of Engineering Department, will consist of one central control centre and one sub-centre as described in the conceptual hardware structure plan. The central control centre will be located in the Engineering Department at KOMTAR and the sub-centre will be located in a government building in Bayan Lepas.

A. Functions of Control Centre

The functions of the central control centre are to monitor the daily traffic conditions, to record statistical traffic data, to initiate countermeasures for road accidents, emergency vehicles or festive events, to act and resolve traffic congestion and finally to supervise all activities including those of the sub-centre.

The functions of the sub-centre in Bayan Lepas are to monitor traffic conditions in that area and relay these information to the central control centre.

B. Staff Requirement

The following qualified personnel will be required to operate the expanded ATC System and to discharge the responsibilities required of the control centre.

(i) One Senior Engineer who is well experienced in traffic management to act as the manager for the control centre.
(ii) One Traffic Engineer.
(iii) One Electronic Engineer.
(iv) Three Operating Engineers to handle the centre round the clock.

C. Organisation of Staff in accordance to the Staging Plan

As described in the preceding section, the ATC System will be expanded stepwise in accordance to the Staging Plan and the system will begin to function comprehensively with the introduction of a host computer in Stage III. Therefore, it will be possible to operate a control centre comprehensively in Stage III.

Staff	Stage I (1987–1990)	Stage II (1991–1994)	Stage III (1995–1997)	Stage IV (1998–2000)	Stage V (Beyond 2000)
Senior Engineer	0	0	1	1	1
Traffic Engineer	0	0	1	1	1
Electronics Engineer	0	0	0	0	1
Operating Engineer	1	2	2	3	3
Total	1	2	4	5	6

Note : A Traffic Management and Control Unit will be established in Stage III.

4.2.6 Estimated Installation Cost

The installation of the proposed expansion of the present Stage I ATC System will require the total amount of M$37.0 million.

The installation cost for Stage II, III and IV is M$7.9 million, M$20.0 million, and M$9.2 million respectively.

However, the total operation cost for the expanded ATC System will be about M$6.5 million and a total of about M$10.0 million will also be required for the renewal of Stages I and II. Thus the total implementation cost of the ATC System Expansion Plan is M$53.5 million.

A breakdown of the amount in each stage is shown in Table 4.4.

Table 4.4 : Installation Cost of ATC System Expansion Plan (M$1000, 1986 Price)

		Stage I	Stage II	Stage III	Stage IV	Total
1.	System Cost					
	Traffic Signal Control System & Statistical Data Collection System	–	4,680 483*	12,328	0 3,869*	21,360
	Closed Circuit Television System	–	1,103	947	375*	2,425
	Driver Information System	–	0	3,427	2,072 1,300*	6,799
	Contingency (10%)	–	627	1,670	762	3,059
2.	Insurance and Others	–	346	894	407	1,647
	Sub-Total	–	7,239	19,266	8,785	35,290
3.	Intersection Improvement Cost	–	611	721	373	1,705
	Total	–	7,850	19,987	9,158	36,995
4.	Operation Cost	–	–	–	–	6,512
5.	Renewal Cost	–	–	–	–	9,993**
	Grand Total					53,500

Notes : Tax is not included in the cost estimation.
Renewal period of the system is 10 years.
* Cost for Bayan Lepas Area.
** Renewal Cost for Stages I & II.

4.2.7 Traffic Engineering Measures related to ATC System

This section introduces the traffic engineering measures related to the ATC System. It is important to implement these measures together with the ATC System in order to enhance its effectiveness.

A. Improvement at Intersections and Roads

It is necessary to improve the geometric design and markings on intersections in conjunction with the expansion of the ATC System's coverage area. Basically, the following improvements are necessary,

(1) Simplification of intersection design

(2) Provision of additional lanes at intersection approach

(3) Proper channelization

(4) Improve road markings and traffic signs

(5) Conversion of congested roundabout intersections into signalized intersections.

However, it is important to maintain roundabout intersections which have sufficient intersection capacity, good landscaping, historical monuments and so forth, such as the roundabouts at Gelugor Road/Green Lane, Gurney Drive/Kelawei Road/Tanjong Tokong Road, Light Street/Beach Street, etc.

B. Improvement of Signal Controlling

The following measures are suggested regarding signal control:

(1) Provision of pedestrian crossing and/or signal at signalised intersection

(2) Improvement of visibility of traffic light

(3) Application of yellow and red flashing control at midnight.

(4) Dimming of traffic signal lights at night

4.2.8 Effects of the ATC System

A. Benefits of the ATC System Expansion Plan

With the implementation of the ATC System Expansion Plan, the following positive effects can be expected.

1. Effects of Traffic Signal System

a. Minimize Traffic Congestion

Traffic congestion is minimized because the coordinated and traffic-responsive operation of signals allow more vehicles to travel along a route within a shorter time.

b. Monitor Malfunctioning of Equipment

The monitoring of malfunctioning equipment benefits road users through reduction of travel time together with increase in intersection capacity and also prevention of traffic accidents.

c. Emergency Vehicle Users

Through pre-emption of the right-of-way through centrally controlled signalized intersections, emergency vehicles (usually fire-fighting vehicles) can arrive quickly at their destinations.

d. Control of Vehicle Speed

It is expected that drivers will drive at or near the progressive speed which is a basic parameter to determine signal timings for coordinated signals. Such an attitude will promote safe, orderly and efficient movement of traffic.

e. Control of Traffic Volume at Certain Locations

By means of centralised signal control, the traffic condition at critical or incident locations from the control centre can be controlled and adjusted to avoid more congestion.

f. Reduction of Noise and Air Pollution

Noise and vibration generated by vehicles are reduced because the number of stops at intersections are lessened. Exhaust gas emitted when starting and stopping is also reduced.

2. Effect of CCTV System

It is obvious from many experiences in other cities that the CCTV System is useful to a centralized traffic control system.

The most significant role of the CCTV in the system is to help the operators identify the need for a special service at the scene of an incident. When the operator wishes to initiate a special service and take action regarding an incident or problem, he needs more visual display of the condition in the system to justify his action.

The CCTV system can be used for multi-purposes related to traffic control as well as non-related functions such as fire fighting etc.

3. Effect of Driver Information System

Information to driver can be of two types:

(1) information that would allow a driver to alter his route through a certain network so that he can avoid an incident point or other undesirable situations,

(2) information that would inform the driver, while travelling on a particular route, of specific problems within the network in order to allay some of his concern, irritation and discomfort without requiring or expecting him to change his routing.

It is expected that the Driver Information System can product savings to motorists by reducing delay time, mental and physical aggravation and frustration. Delay time can be reduced through voluntary diversion and through more efficient traffic operations.

4. Effects of Statistical Data Collection System

Detector data would be recorded automatically in tapes or disks, and summarized periodically as statistics reports. The reports could be useful and valuable for research, traffic study, transportation planning and so on.

B. Evluation of Stage I ATC System

Several position effects have already emerged from the operation of Stage I ATC System.

Based on evaluation of improvement to traffic conditions by the introduction of the Stage I ATC System, the following benefits have been achieved. To evaluate the ATC System, traffic surveys 'before' and 'after' the installation were conducted.

1. Travel Time

It is observed that the travel time on most of the seven routes under surveyed has been reduced.

On the whole, the morning peak travel time has been reduced by 15%, afternoon peak time by 12% and evening peak time by as much as 22%. Thus, on the average, the travel time along all the routes considered has been reduced by about 16%.

Figure 4.9 depicts the total travel time difference obtained from surveys conducted 'before' and 'after' installation of the ATC System along the seven major routes in the city in connection with the Stage I installation.

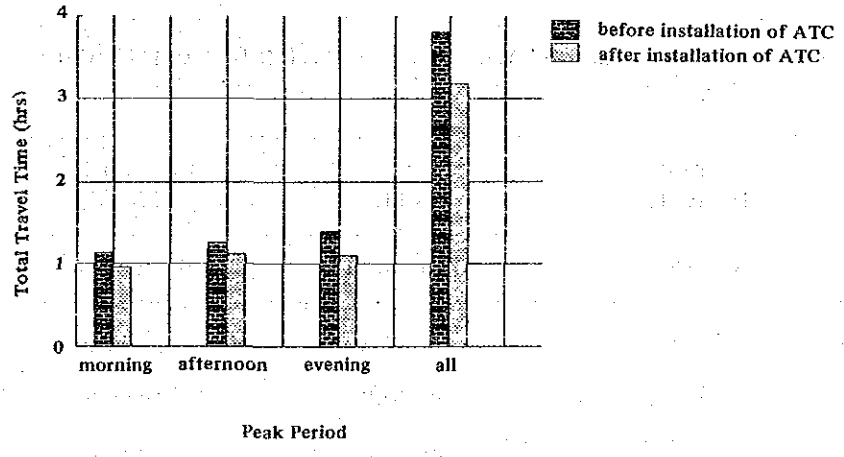


Figure 4.9 : Travel Time Difference

2. Delay Time

For the intersections covered under the Stage I ATC System the morning and evening peak delay times have been reduced by 34% and 25% respectively whereas the daily delay time has been reduced by 28%.

The Stage I ATC System is expected to reduce annual delay time by approximately nine hundred and seventy thousand (970,000) hours or a reduction of 28% from the annual delay time of 3.5 million hours before the introduction of ATC System.

3. Benefit Estimate for the Stage I ATC System

The benefit derived from computerization of signalized intersections can be measured by the difference in transport cost.

From the estimates, time value saving is M$3.7 million and fuel saving is M$0.6 million. Overall, the Stage I ATC System is expected to gain an annual benefit of approximately M$4.3 million or to save 28% of the annual transport cost (M$15.3 million) before the operation of the ATC System.

Table 4.5 presents the annual delay time and annual transport cost estimated for both 'before' and 'after' installation and it also shows the difference between both studies.

Table 4.5 : Annual Delay Time and Annual Transport Cost 'Before' and 'After' the Installation of Stage I ATC System

	Annual Delay Time *	Time Value ** $3.80	Fuel Cost + M$0.57	Annual Transport Cost
	x 1000 hr	M$ x 1000	M$ x 1000	M$ x 1000
Before	3498.2	13293.2	1994.0	15287.1
After	2525.5	9596.9	1439.5	11036.4
Saving	972.7	3696.3	554.4	4250.7
				(27.8%)

* : Computed on a basis of 250 days

** : Taken as M$3.80 per PCU hr.

\+ : Taken as M$0.57 per PCU hr.

4.3 Proposed Regional Transportation Plan

4.3.1 Introduction

In view of the future expansion of the urbanized area and the countermeasures taken to cope with the resulting increase in transport demand, the following transportation plans are necessary to ensure public safety and to secure mobility for the people.

- Road Network Improvement Plan
- Bus Transport Improvement Plan
- Traffic Safety Measures and Others

Therefore the proposed Regional Transportation Plan will comprise the abovementioned transportation plans as illustrated in Figure 4.10.

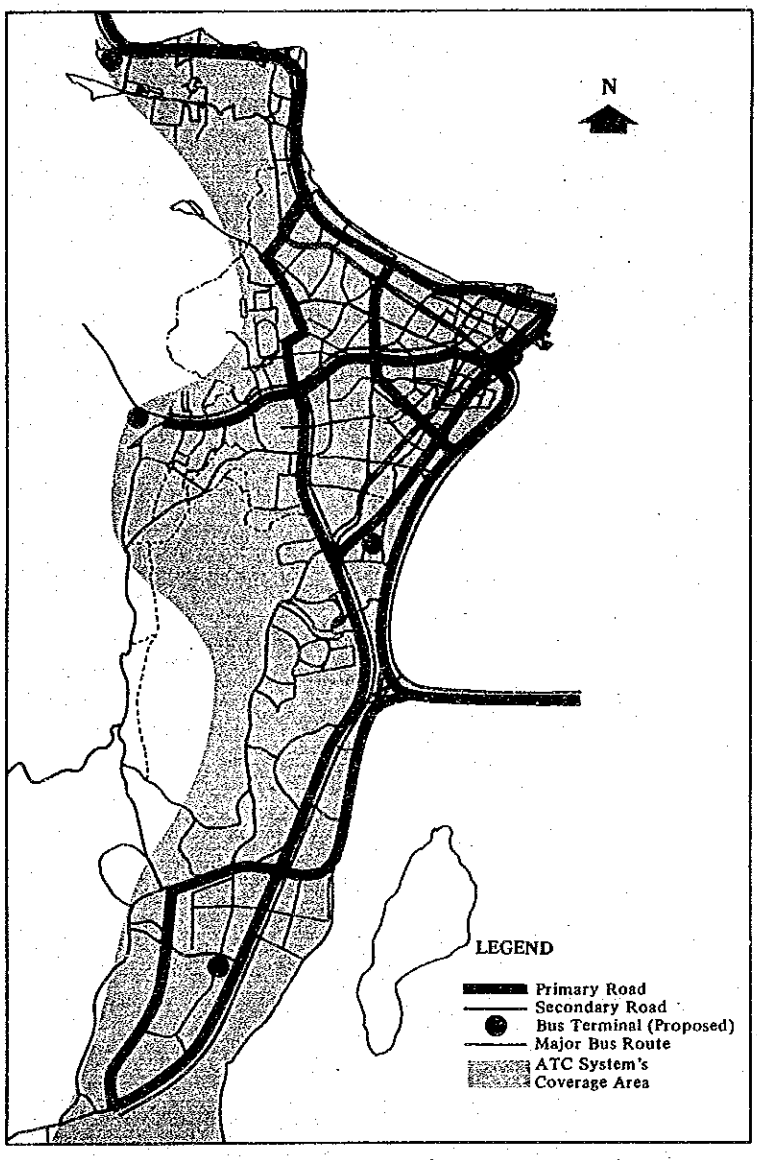


Figure 4.10 : Proposed Regional Transportation Plan

4.3.2 Road Network Improvement Plan

The proposed road network configuration in the Study Area is a partially developed radial and circumferential network as shown in Figures 4.11 and 4.12.

In this Study, roads are classified into three (3) categories accordng to their function. The following are the definitions of the categories.

1. **Primary Road**

   These roads are designed to provide a high level of service and a large traffic capacity since they are used to distribute long trip, inter-city and intra-city traffic. All long distance traffic to, from and within the town should be channelled to these roads.

2. **Secondary Road**

   These roads distribute traffic within the main residential, industrial and business districts of the town while forming the link between the primary network and the roads within the surrounding areas. It performs a vital function of accommodating maximum traffic movement during peak periods and serves the general circulating and land service functions of the community during off-peak periods.

3. **District Road**

   Although these roadways are sometimes such for traffic movements through the city, they are generally utilized for local circulating purposes within the surrounding areas and form a necessary link between secondary roads and access roads.

Based on the road network configuration for year 2000, traffic assignment result is obtained and illustrated in Figure 4.13.

In response to the increasing traffic demand and to establish a hierarchical road network in the Study Area, the following road projects are necessary:

			Index on Figures 4.11 and 4.12
A.	**New Construction**		
1.	Primary Roads:		
a.	Coastal Road	4.3 km	1
b.	Weld Quay Extension	4.1 km	2
c.	South Coastal Road	3.4 km	3
2.	Secondary Roads:		
a.	Ayer Itam By-pass	4.0 km	5
b.	New Pair Road	4.9 km	4
c.	Van Praagh Road Extension (Hamilton Road – Weld Quay Extension)	1.7 km	6
3.	District Roads:		
a.	Free School Road Extension (Free School Road – Patani Road)	0.8 km	7
b.	Trengganu Road Extension (Ayer Itam Road – York Road)	0.4 km	9
c.	Boundary Road Extension (Boundary Road – Batu Gantong Road)	1.2 km	8
B.	**Road Improvement**		
1.	Dato Keramat Road Improvement	0.5 km	10
2.	Perak Road Improvement	0.5 km	11

(Note : These two (2) road improvement projects are to be carried out by widening the existing roadway to a uninterrupted 2-lane dual carriageway within the limits of the existing right-of-way.)

C. Intersection Improvement

One hundred and thirty-three (133) intersections require improvements in conjunction with the implementation of the ATC System Expansion Plan.

D. Road Network Beyond 2000

Construction of the Outer Ring Road is deemed necessary only after the year 2000 in order to complete the desired road network configuration and to cater for increasing traffic demand in Penang Island.

In view of the traffic conditions at Dato Keramat Road/Perak Road Intersection, it will be timely after the year 2000 to consider grade separation by constructing a flyover over Perak Road.

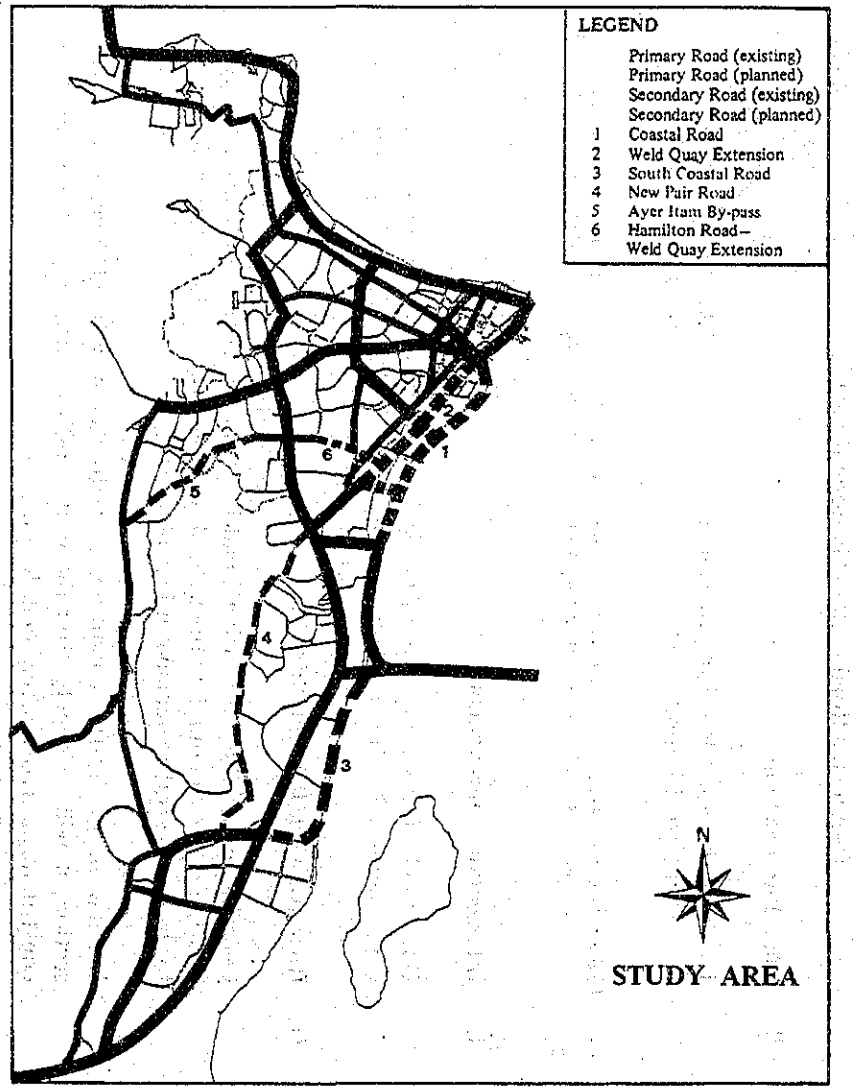


Figure 4.11 : Proposed Road Network Configuration in Study Area

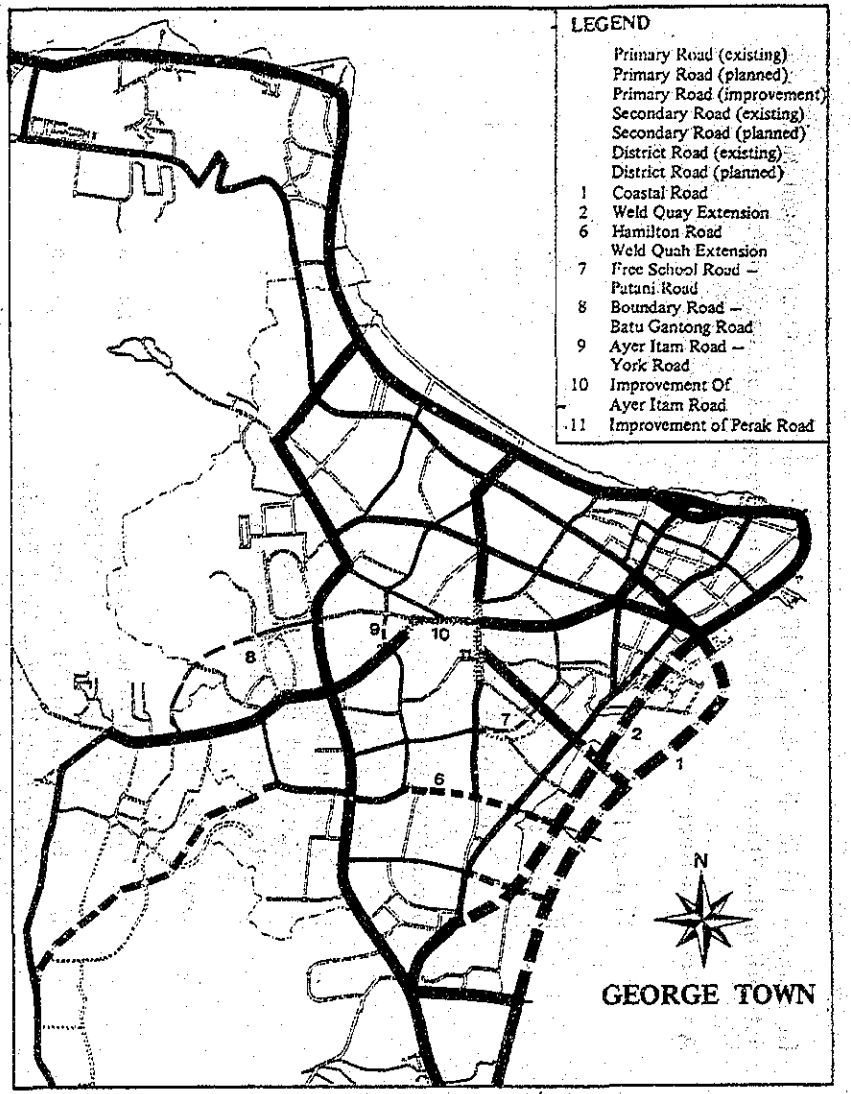


Figure 4.12 : Proposed Road Network Configuration in George Town

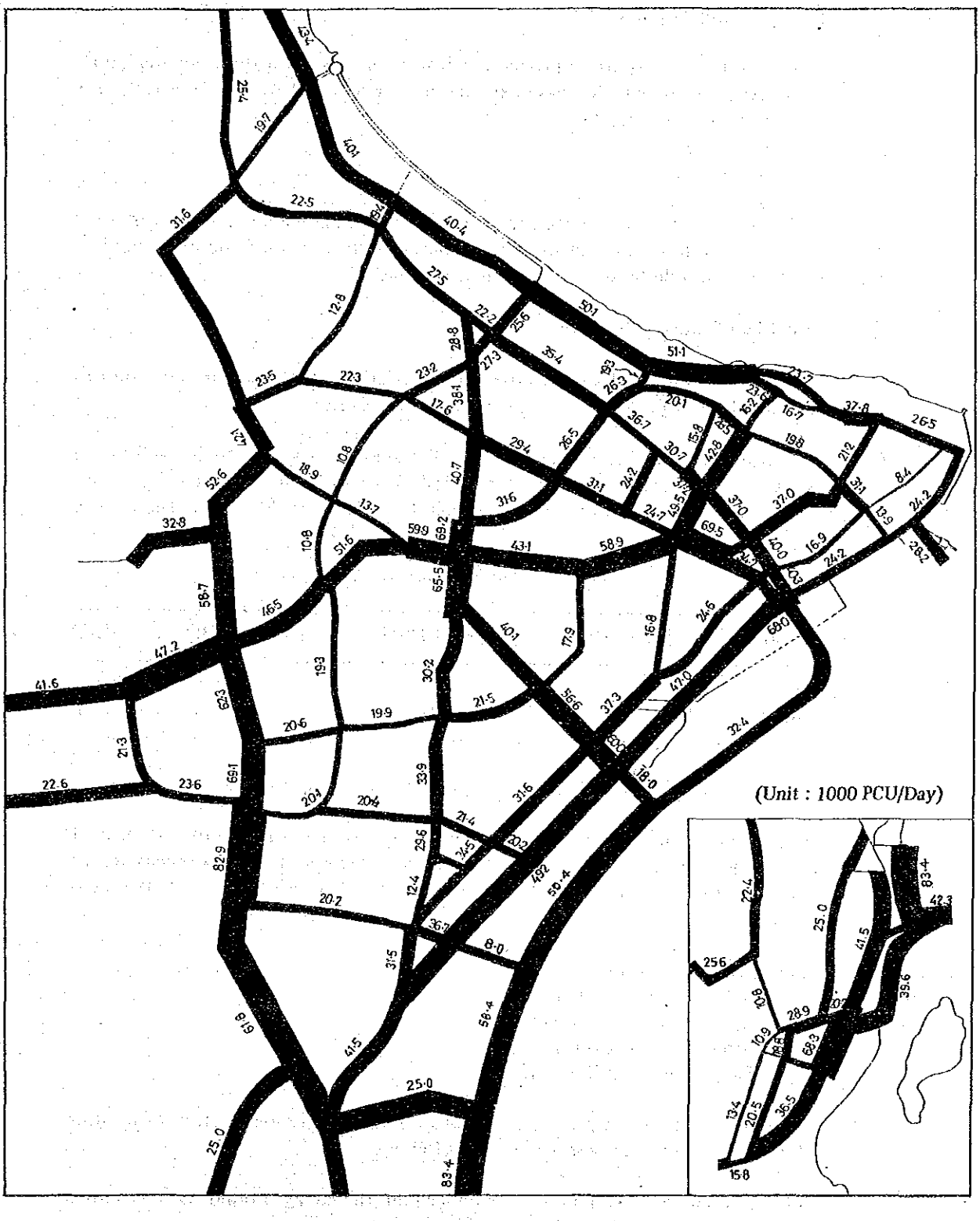


Figure 4.13 : Future Traffic Assignment on Road Network, 2000

4.3.3 Bus Transport Improvement Plan

The following Bus Transport Improvement Plan is proposed for the whole region in the Study Area in order to increase existing bus services and to make bus ridership more attractive and convenient.

A. Bus Transport Study

A bus transport study is necessary in order to formulate a bus transport master-plan to determine the future role of bus transport vis-a-vis the other modes. This study should be started as soon as possible.

B. Bus Fleet Renewal Program

It is necessary to replace old buses in the existing bus fleets in order to ensure dependability of bus services and comfortable bus rides.

According to existing regulations, the life span of a stage bus is twelve (12) years. On this basis, one hundred and forty (140) replacement buses are estimated to be required between year 1988 to year 2000 (see Table 4.6).

Table 4.6 : Bus Fleet Renewal Programme

Period	1988–1990	1991–1995	1996–2000	Total
No. of Buses	25	70	45	140

C. Bus Terminal Improvement and Reorganization of Bus Route Network

Construction of a bus terminal in the Central Area and local bus terminals at the major stopping points in the suburbs of George Town are necessary to improve the level of bus services. The proposed terminals to be constructed are:

(1) CBD Bus Terminal
(2) Gelugor Bus Terminal
(3) Ayer Itam Bus Terminal
(4) Bayan Baru Bus Terminal
(5) Tanjong Bungah Bus Terminal

Together with the improvement of bus terminals, a reorganization of existing bus route networks is also proposed as follows:

(1) a Zone Bus System be introduced in the areas around Ayer Itam Bus Terminal and Bayan Baru Bus Terminal,

(2) operation of limited express bus services (CBD–Bayan Baru Area) using the Coastal Road,

(3) inter-regional (express) bus service be introduced.

The concept of the Bus Transport Improvement Plan for the Study Area is shown in Figure 4.14.

However, in this study only the determination of a location for the proposed CBD Bus Terminal will be further discussed in the forthcoming Section 4.4.3.

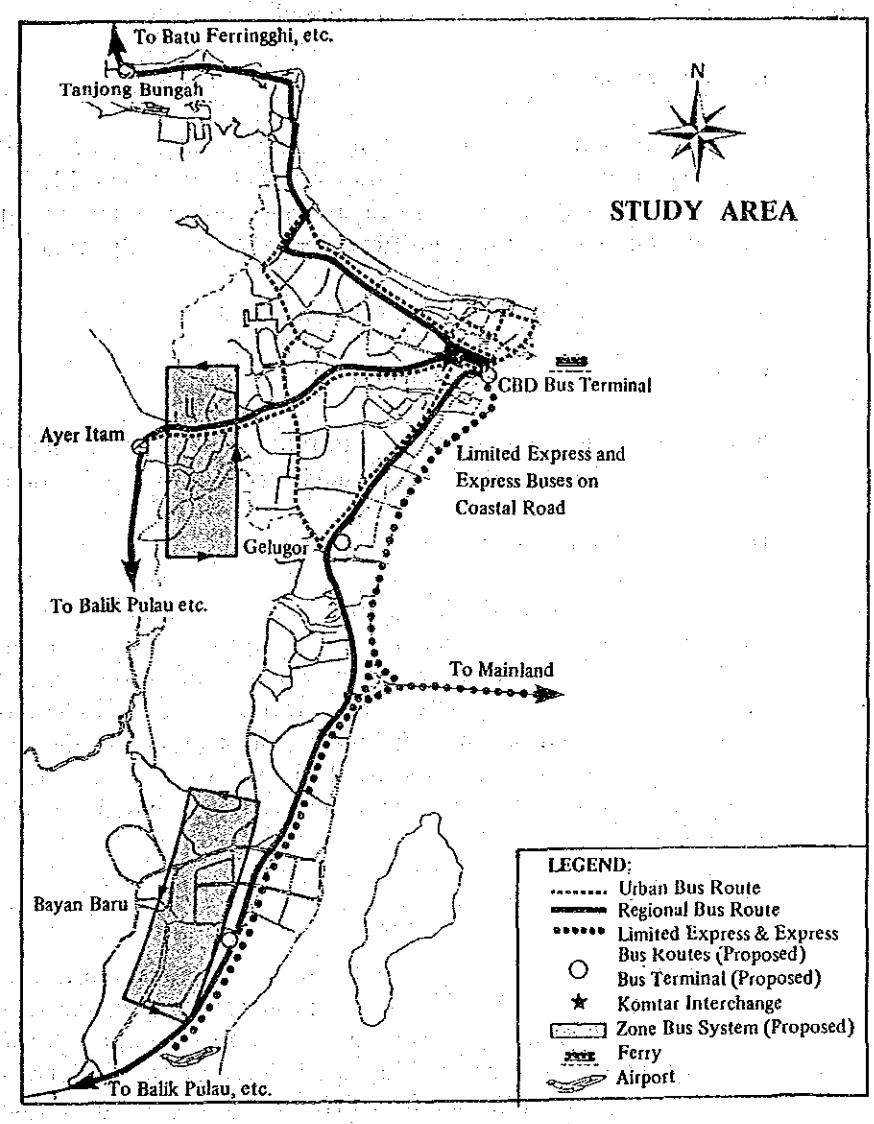


Figure 4.14 : Desirable Concept of Bus Transport Improvement Plan

4.3.4 Traffic Safety Measures and Others

The solutions to transport problems are not merely restricted to the implementation of hardwares such as traffic control system or road network improvement.

There are other meausres, for example, education on traffic safety and proper enforcement of traffic regulations, improvement of road markings, etc. which can also promote the mitigation of transport problems.

Therefore, the following measures are also proposed.

A. Traffic Safety Measures

Traffic safety remains a matter of major concern all over the world. Every effort is being made to look into various aspects of the problem, especially improved environment, education, engineering, enforcement of safety rules, and other human factors. It is no different here in the Study Area.

Thus the following measures are proposed.

1. Improvement of Pedestrian Facilities

   'Pedestrian-vehicle' collisions have resulted in severe or even fatal injuries. It is urgent that every effort be made to improve pedestrian facilities.

2. Data Processing for Accidents

   Accident records are kept in the traffic sections of the Police Department. However, statistics of accidents and analytical reports are not always available to the City Engineering Department, educational institutions and other agencies concerned with traffic safety. Therefore, it is recommended that a uniform system of data processing methods be established first, to be followed by the identification of accident locations and the analysis of the causes of accidents based on accumulated analytical data.

3. Promotion of Traffic Safety Education

   Education regarding road-use and adequate information campaigns is equally important. Application of proper traffic engineering methods induces self-education to a certain extent; for example, drivers tend to drive within a lane when markings are painted on streets; when driving on streets with proper lane markings, drivers acquire the habit of not weaving too frequently.

4. Stricter Enforcement of Traffic Rules and Regulations

Proper and stricter enforcement of traffic rules and regulations is essential to attain a safe and smooth operation of traffic facilities.

B. Other Measures

1. Better Road Markings and Signs

Basically the installation of better road markings and signs which are clearly visible and easy to follow must be implemented earnestly throughout the Study Area. The general guidelines for such installations have been already described in the traffic engineering measures related to the ATC System Expansion Plan (See Section 4.2.5).

2. Control and Conservation of Trishaw

The current MPPP policy of not issuing new trishaw licences should be pursued. However, it is undeniable that the trishaw is still one of the existing transportation modes in George Town. Thus it is desirable that in the short-term the trishaw would remain in the Central Area for local services such as trips to school and the market until public transportation provided by buses and taxis is improved. In the long-term, the trishaw should only function for tourism – related purposes.

Furthermore, it is suggested that the trishaw should not be allowed to cross a primary or main district road. Therefore, basically, the movement of trishaw would be restricted to within areas enclosed by primary and main district roads.

The immediate application of this planning concept to the Central Area of George Town is to prevent the slow-moving and obstructive trishaw from going through the congested KOMTAR area. This measure will increase the road capacity of the existing road network without new investment and will increase road safety.

The trishaw can be said to be part of Penang's rich heritage. To many tourists visiting the island, a ride on the trishaw along streets lined by old shophouses, temples and magnificient old buildings is exotic. It is also an economical and convenient transportation mode for tourists to move around the urban area.

Therefore it is suggested that the trishaw be conserved for tourism and that space for the trishaw be allocated near the tourist attraction areas.

3. Control of Illegal Taxis

The issue of illegal taxis is complex: on one hand, it could be said that the presence of illegal taxis has impeded the development of taxi and stage bus services. On the other hand, the poor level of service of public

transportation could be blamed for creating the illegal taxi service in the first place.

Although being a pain in the neck to the enforcement authorities, the illegal taxi appears to be popular with the common man who prefers this alternative to a long wait for the bus or taxi. Therefore any counter-measure to the illegal taxis must reconsider the needs and convenience of those people without their own means of transport. Illegal taxis should be eradicated by the simultaneous improvement of public transport facilities as well as stringent and continuous enforcement by police.

Furthermore, it is proposed that a study be made on the necessary changes to the existing regulations governing taxi operation to make legal taxis more competitive and efficient.

4. Restriction of Hawker Movement

Hawkers should be prohibited from hawking their wares on primary, secondary and district roads entirely if possible; otherwise their hawking should be restricted to specific periods, special days and specific locations.

5. Preservation of Environment

In Penang, the following three points on environmental preservation as seen from the traffic perspective should be noted:

a. Preservation of the Residential Environment

b. Preservation of Old Trees along Roadways

c. Preservation of Historical Buildings and Ruins

4.4 Proposed Central Area Transportation Plan

4.4.1 Introduction

The main objectives of the Central Area Transportation Plan are to improve public safety and to secure mobility for the populace in order to encourage economic activities in the Central Area.

In this plan, car traffic, bus traffic and pedestrian traffic are the three (3) types of mobility which are to be increased by a balanced and orderly utilization of road space. The net result will be related to the increase in economic activities within the Central Area.

Conceptually, the Central Area Transportation Plan comprises two (2) main axes. These are:

1. Pedestrians and Vehicles Segregation Axis

   The provision of sufficient space for vehicles and pedestrians in the central business and commercial areas will ensure mobility of vehicles and people, who are the lifeline of commercial and business activities.

   The road forming the Pedestrians and Vehicles Segregation Axis is to be provided with sufficient road space for vehicle alongside a continuous space for pedestrians to coexist with orderly traffic flow rectified by measures such as signal control, channelization of traffic flows, one-way streets, etc. Figure 4.15 illustrates a typical cross-section of an axis for the coexistence of pedestrians and cars.

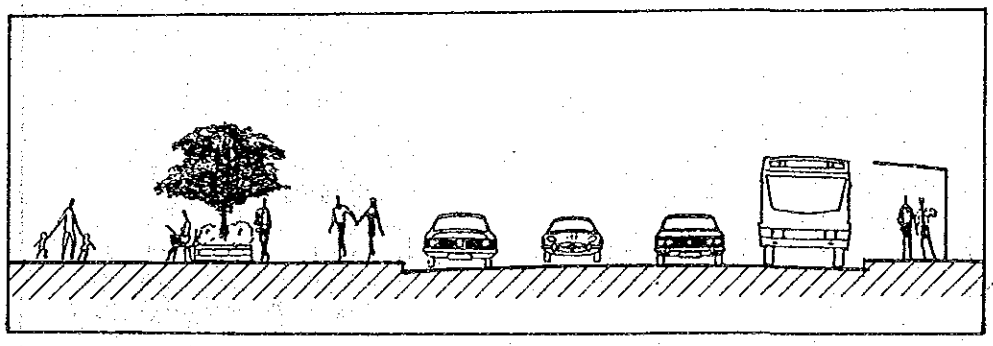


Figure 4.15 : Typical Cross-section of a Pedestrians and Vehicles Segregation Axis

2. Pedestrian Path Axis

The installation of pedestrian paths at the expense of space for vehicles on urban streets is proposed to complement the proposed pedestrians and vehicles segregation axes, in order to form a pedestrian path network. Therefore the following improvement plans are proposed:

a. Construction of a promenade for strolling along the sea front and around the historical ruins, i.e. along the Esplanade, which is one of the main attractions in George Town.

b. Construction of pedestrian paths in relation to the preservation of historical buildings and introduction of aesthetic urban designs and at the same time providing support to the travel demand of the business district.

c. Construction of pedestrian paths in the existing shopping areas to induce even more trips to the shopping centres.

d. Construction of a pedestrian path to link the Ferry Terminal with the proposed CBD Bus Terminal.

Together with the construction of pedestrian paths, at the appropriate locations, and construction of pedestrian decks are also proposed to ensure a continuity of pedestrian accessibility.

Figure 4.16 illustrates a perspective view of proposed pedestrian paths along Campbell Street.

Figure 4.16 : A Perspective View of Proposed Pedestrian Paths along Campbell Street

The concept of the Central Area Transportation Plan is shown in Figure 4.17. The components of this plan are:

Traffic Circulation System Improvement Plan
Bus Transport Improvement Plan
Pedestrian Path Network Plan
Parking Plan
Other Proposed Measures

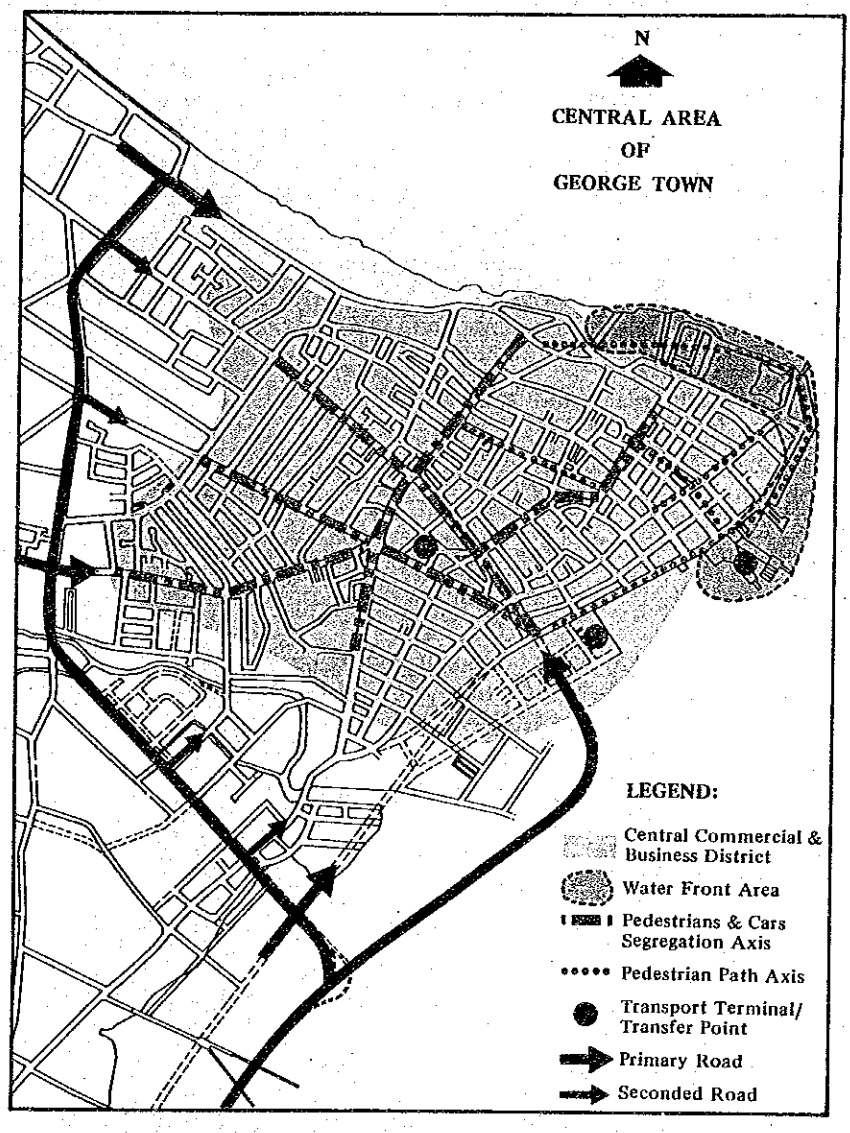


Figure 4.17 : Concept of Central Area Transportation Plan

4.4.2 Traffic Circulation System Improvement Plan

A, General

A good traffic circulation system produces a more efficient and smoother traffic flow. It is widely used as a traffic management technique especially in heavily trafficked urban areas.

Analysis on existing traffic conditions and the future vehicle OD distribution pattern shows that the circulation system around Komtar is expected to face serious traffic congestion in the future. A contributory factor is the situation whereby most of the traffic circulation within the Central Area is concentrated in the periphery of KOMTAR. Hence, remedial measures are desirable to improve the existing circulation system, to upgrade traffic flow, road safety, and to increase carriageway/intersection capacity.

B. Traffic Circulation Alternatives

At this juncture, one alternative short-term plan, and two alternative long-term plans are being considered for the future one-way circulation system.

The conceptual strategy is to (a) provide a more efficient and smoother traffic flow, (b) reduce the traffic volume in the periphery of KOMTAR, and (c) increase the carriageway and intersection capacity and furthermore (d) improve or construct pedestrian pathways. The basic features of the existing system and of these alternatives are briefly listed below. Further details are presented in Figure 4.18.

1. Existing Circulation System

Under the existing circulation system, the major traffic control features are:

(1) One-way north-bound on Penang Road between Prangin Road and Magazine Circus, one way south-bound on Ria Road as its pair;

(2) One-way west-bound on Magazine Road between McNair Street and Magazine Circus, one way east-bound on Prangin Road from Penang Road to Ria Road;

(3) One-way south-bound on Penang Road between Chulia Street and Prangin Road, one-way north-bound on Transfer Road;

(4) Basically, a series of one-way loops (combined loops system) is adopted in the Central Area of George Town, that is, the one-way loop formed by the roads mentioned in the above items (1) and (2) is connected at the intersection of Penang Road and Prangin Road with another one-way loop formed by Burma Road, Transfer Road and Phee Choon Street.

2. Short Term Alternative

Alternative S–1: To a certain extent the circulation is identifical to the existing system. Major changes involve conversion of some major roads into one-way and reversal in traffic flow of some existing unidirectional streets. Planning of this circulation is based on the assumption that the new Coastal Road will not be in operation by 1990.

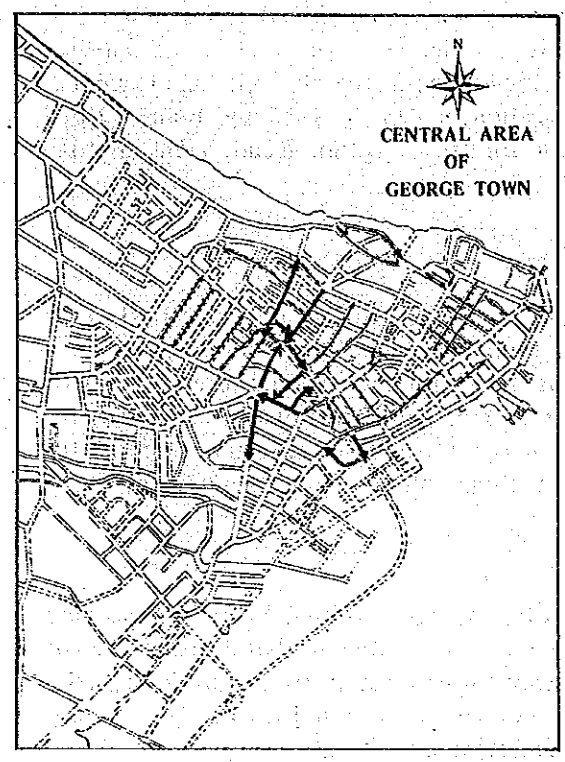
3. Long Term Alternatives

The usage of main roads and some buildings around KOMTAR has been decided under the KOMTAR Project. According to that decision, Prangin Road will be operated as one-way for east-bound traffic, while Magazine Road will be controlled as one-way for west-bound traffic. These roads will be directly connected to the new Coastal Road.

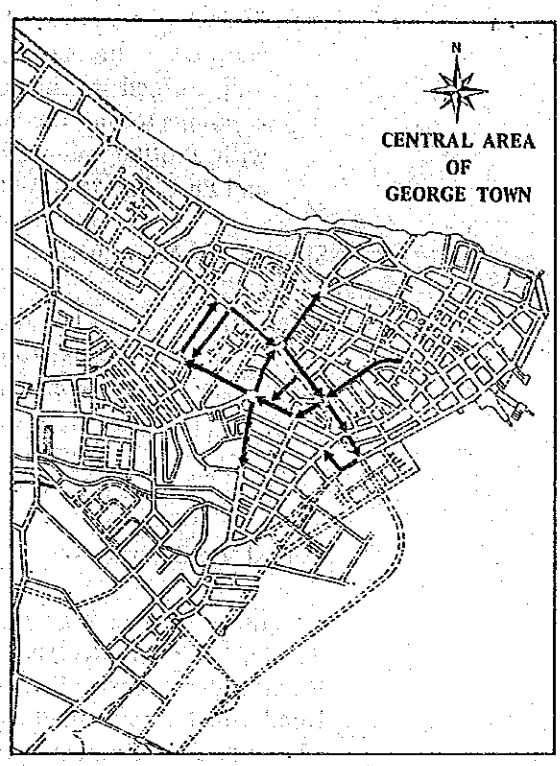
Therefore, the following alternatives L–1 and L–2 are considered under the KOMTAR Project Plan.

Alternative L–1: Basically, the circulation is identical to the existing system involving some minor changes. This circulation shall accommodate the traffic impact introduced by the new Coastal Road, presumably to be in operation by 2000.

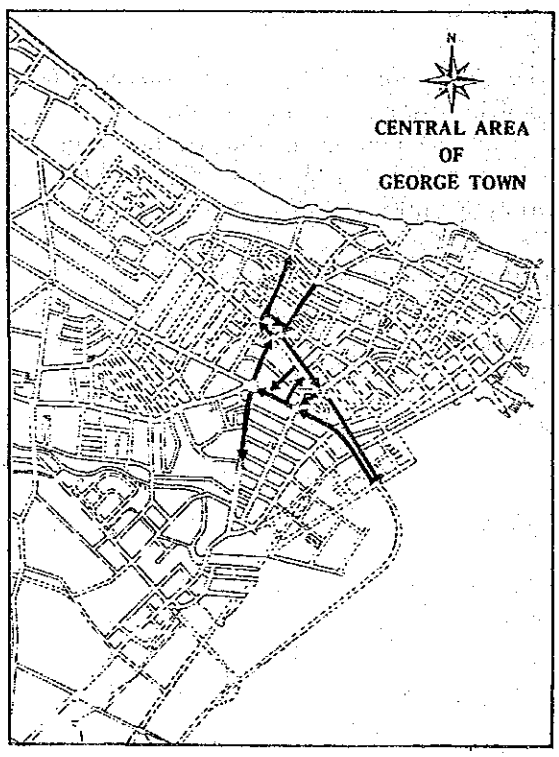
Alternative L–2: The circulation is identical to Alternative S–1, but involves some major changes from the existing system in view of the impending traffic impact introduced by the new Coastal Road by the year 2000.



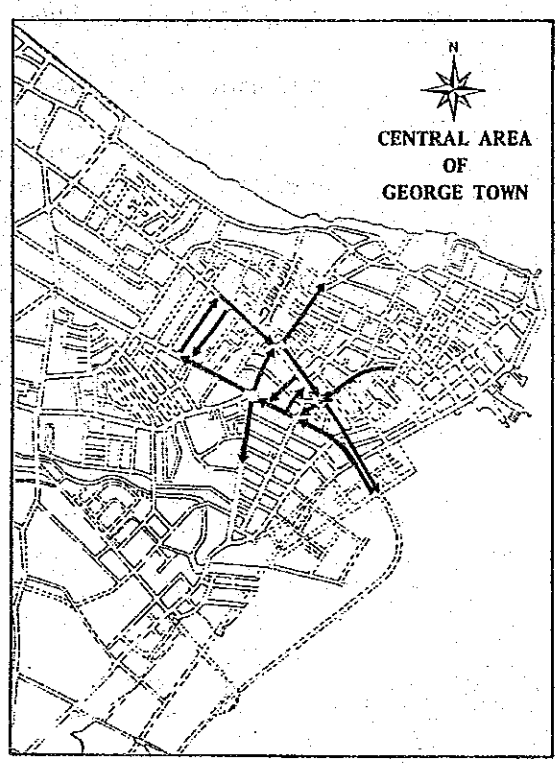
Existing Circulation Plan (1987)



Alternative S–1 (1990)



Alternative L–1 (2000)



Alternative L–2 (2000)

Figure 4.18 : Traffic Circulation Alternative Plans

C. Examination of Alternative Traffic Circulation Plan

In order to examine each traffic circulation plan, the traffic volume in the periphery of KOMTAR is estimated using traffic assignment simulation method. For example, Figures 4.19 to 4.20 show the traffic volume under the Existing Plan for 1990 and Alternative L–2 for 2000.

1. Short term plan

a. Total trip distance, Total Travel time and Average Speed

Table 4.7 shows the total trip distance in vehicle-kilometers, total travel time in vehicle-hours and average speed in kilometer per hour in the Central Area of George Town in 1990. The comparison between Existing Plan and Alternative S–1 for short term plan shows that the values of each factor are almost similar in both cases. However, the value of vehicle kilometers logged under the existing system plan is slightly higher than that of Alternative S–1.

Table 4.7 : The Comparison of Vehicle-kilometers, Vehicle-hours and Average Speed, 1990

Indicator	Circulation Plans	
	Existing	Alt.S–1
Vehicle-kilometers ('000 pcu km)	209.4	208.5
Vehicle-hours ('000 pcu hr)	11.0	11.0
Average Speed (Km/hr)	19.0	19.0

b. Road Capacity and Traffic Flow

The roads expected to experience congestion is almost similar in both circulation system plans. They are listed here in order of degree of seriousness, viz., Bridge Street, Dato Keramat Road, Burma Road, Magazine Road. However, the congestion in Burma Road is expected to ease off when it becomes one way in Alternative S–1.

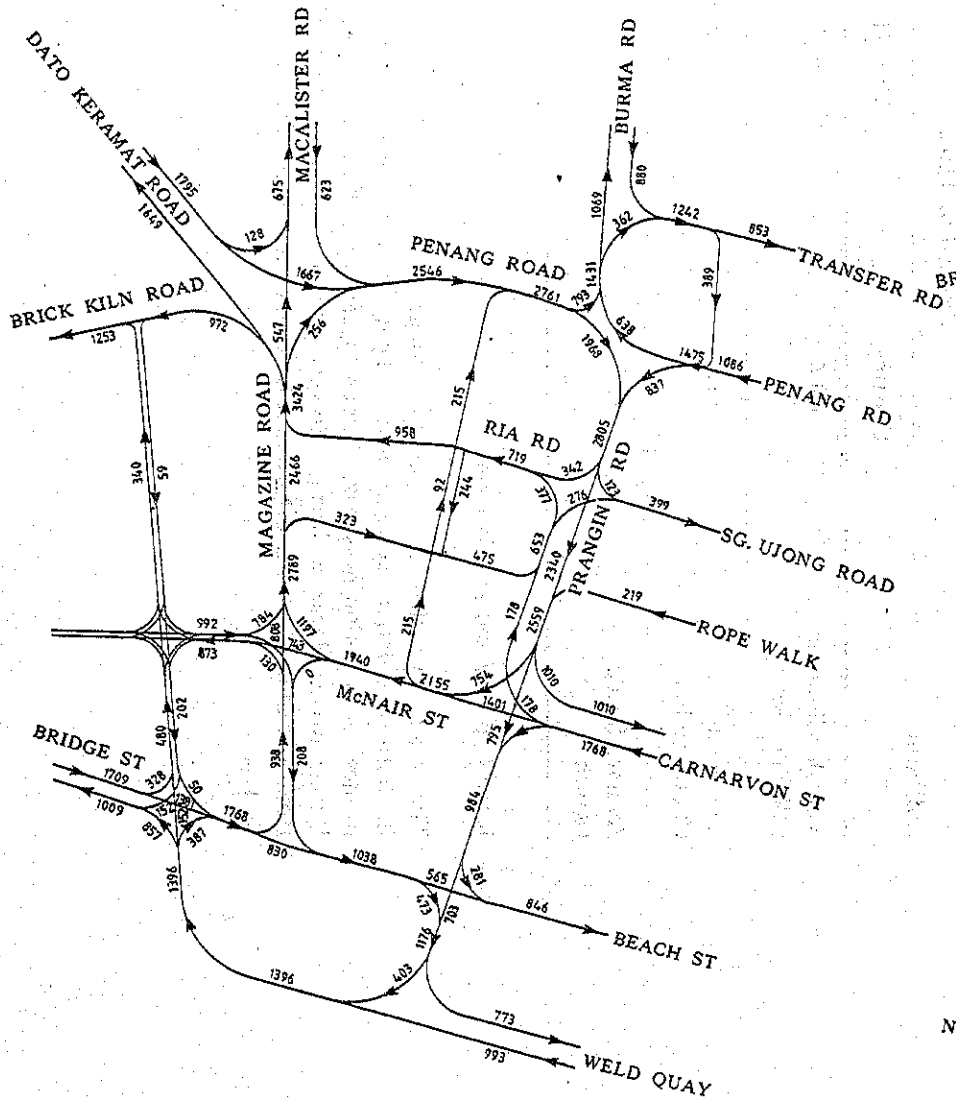


Figure 4.19 : Traffic Circulation Alternative Plan (Existing System Plan) and Traffic Volume in 1990

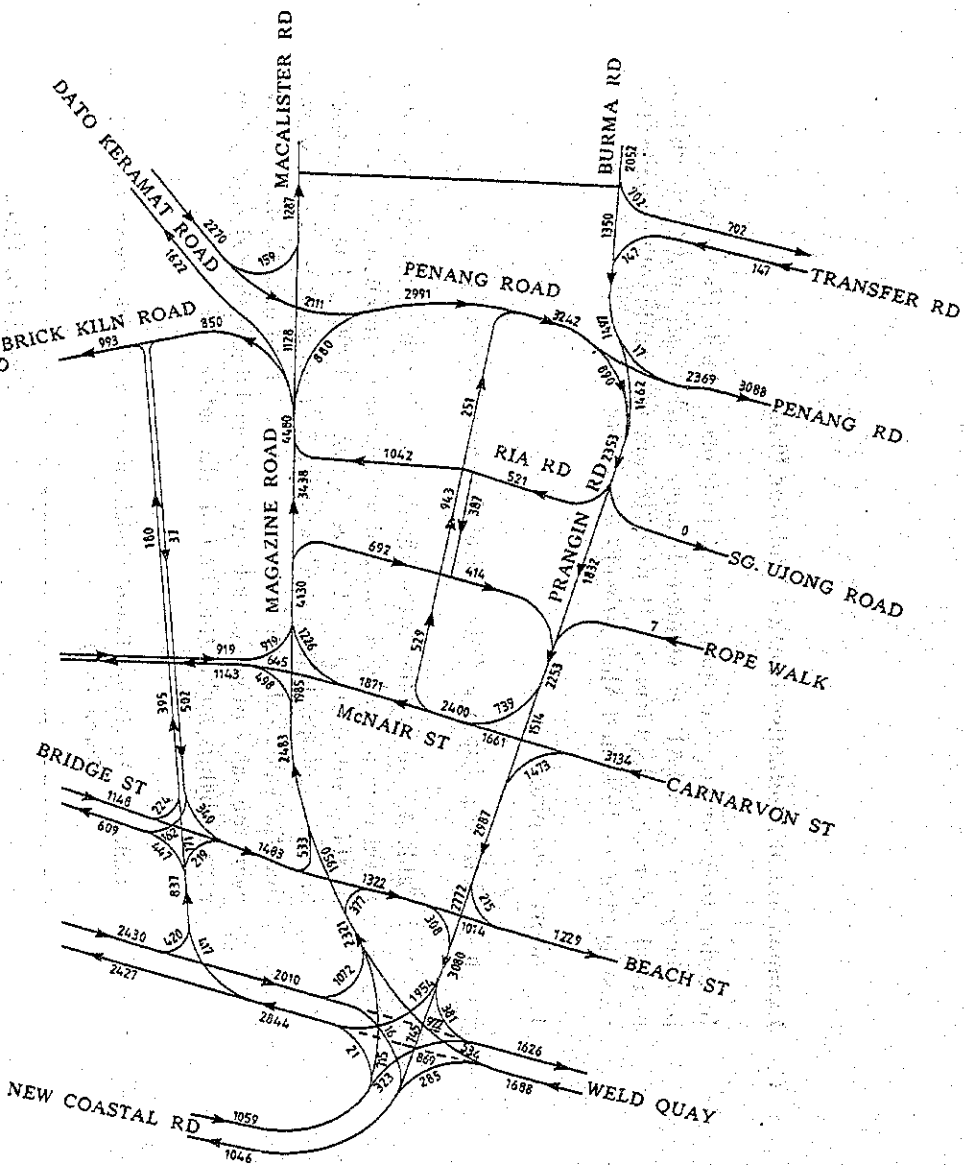


Figure 4.20 : Traffic Circulation Alternative Plan L–2 and Traffic Volume in 2000

c. Intersection Capacity and Traffic Flow

The intersection of Prangin Road/Penang Road and Prangin Road/ Carnarvon Street will have slight congestion in case of the Existing Plan, while in case of Alternative S–1, congestion will not appear, but Magazine Intersection will become slightly crowded.

2. Long term plan

a. Total trip distance, total travel time and average speed

Table 4.8 shows total trip distance, total travel time and average speed in the Central Area, under the alternative traffic circulation plans for 2000.

The values of vehicle-kilometers and vehicle-hours under Alternative L–1 is larger than those of Alternative L–2: that is, motorists will make longer trip lengths and travel longer hours in the Central Area in the case of Alternative L–1. Therefore, the average speed in this case is slower than in Alternative L–2.

Table 4.8 : Comparison of Vehicle-kilometers, Vehicle-hours and Average Speeds, 2000

Indicator	Alternative Circulation Plans	
	Alt.L–1	Alt.L–2
Vehicle-kilometers ('000 pcu km)	287.9	284.2
Vehicle Hours ('000 pcu hr)	17.5	17.0
Average Speed (km/hr)	16.5	16.7

b. Road Capacity and Traffic Flow

Table 4.9 shows estimated congestion degree on the road sections where the demand will exceed the road capacity under either of the alternative plans.

Table 4.9 : Congestion Degree on Road Section (Volume/Capacity), 2000

Road Name	Circulation Plans	
	Alt.L–1	Alt.L–2
Magazine Road	1.28	1.24
Prangin Road between Penang Road and Ria Road	1.18	(0.65)
Carnarvon Street	1.22	(0.87)
Dato Keramat	1.16	1.22
Burma Road	1.11	(0.86)
Penang Road between Magazine Road and Prangin Road	1.02	(0.90)

Notes : 1. The selected roads are expected to carry traffic volume exceeding the road capacity in either case

2. ( ) shows congestion degree under 1.0

From the table, traffic conditions on Carnarvon Street and Burma Road will be congestion-free under Alternative L–2 by means of one-way operation. In addition, Prangin Road will also be congestion-free.

In both alternatives, the demand on Magazine Road and Dato Keramat Road will exceed the road capacity, and on Penang Road between Magazine Road and Prangin Road the demand will approach capacity.

c. Intersection Capacity and Traffic Flow

Table 4.10 shows estimated congestion degree on the intersections where the demand will exceed the intersection capacity under either of the alternative plans.

Table 4.10 : Congestion Degree on Intersection (Volume/Capacity)

Intersection Name	Circulation Plans	
	Alt.L–2	Alt.L–2
Prangin Rd/Penang Rd	1.53	(0.93)
Prangin Rd/Carnarvon St	1.53	1.05
Magazine Intersection	(0.89)	1.32

Notes : 1. The selected intersections are expected to have traffic volume exceeding the intersection capacity.
2. ( ) shows congestion degree under 1.0

Under Alternative L–1, the intersections at Prangin Road/Penang Road and Prangin Road/Carnarvon Street will have serious congestion. On the other hand, under Alternative L–2, Magazine intersection will have heavy congestion. Therefore, since the intersection of Prangin Road/Carnarvon Street has not been improved yet, it is necessary to carefully redesign it.

D. Proposed Plan for Traffic Circulation System

In order to basically ease the traffic pressure in the centre of town, it is important to construct the Coastal Road and/or the extension of Weld Quay as well as to improve the ring roads, namely Perak Road and Western Road – Gottlieb Road – Bagan Jermal Road. The adoption of a new traffic circulation system per se cannot basically mitigate traffic problems.

a. Proposed Short Term Plan

Figure 4.21 shows the proposed short term plan for the traffic circulation system in the Central Area.

In the short term, it is not desirable to change the existing circulation system around KOMTAR, despite of several demerits such as mixed road usage by long-trip and short-trip vehicles, short weaving sections, concentration of most traffic, etc.

To change the existing system, it will have to be necessitated by an occasion, for example, the opening of Coastal Road and/or Weld Quay Extension. Also, even if the existing system is changed before then, this plan's ability to decrease traffic congestion is in doubt.

Thus, existing roads under the present system should be improved by other measures such as advanced traffic signal system, enforcement of parking control and booking of reckless drivers, better road markings, minor road improvements, etc. to ensure smooth traffic flow. Furthermore, it is necessary to construct or widen roads in the periphery of KOMTAR according to a staging plan aiming towards long term improvement.

b. Proposed Long Term Plan

Figure 4.22 shows the proposed long term plan for the traffic circulation system in the Central Area.

After the opening of Coastal Road and/or Weld Quay Extension, the existing circulation system will have to be changed or modified according to the access roads for these new roads and the traffic demand pattern which will be different from the existing one.

Comparing the two alternative traffic circulation plans, Alternative L–2 is the more preferable plan from the viewpoint of traffic engineering.

The main reason for this is that by means of one-way operation on Macalister Road, Burma Road and Carnarvon Street, pedestrian paths with wide widths can be provided on these roads for pedestrians to walk about easily and comfortably. Improved pedestrian facilities will become necessary in the near future in view of the increasing urban pedestrian demand.

However, no matter whichever plan is adopted, the widening or improvement of the roads around KOMTAR such as Penang Road, Magazine Road and Dato Keramat Road will be necessary to ensure smoother traffic flow.

This Study is made using the traffic circulation plan based on the existing KOMTAR Project Plan. However, if the KOMTAR Project Plan is changed it will be necessary to consider other alternatives.

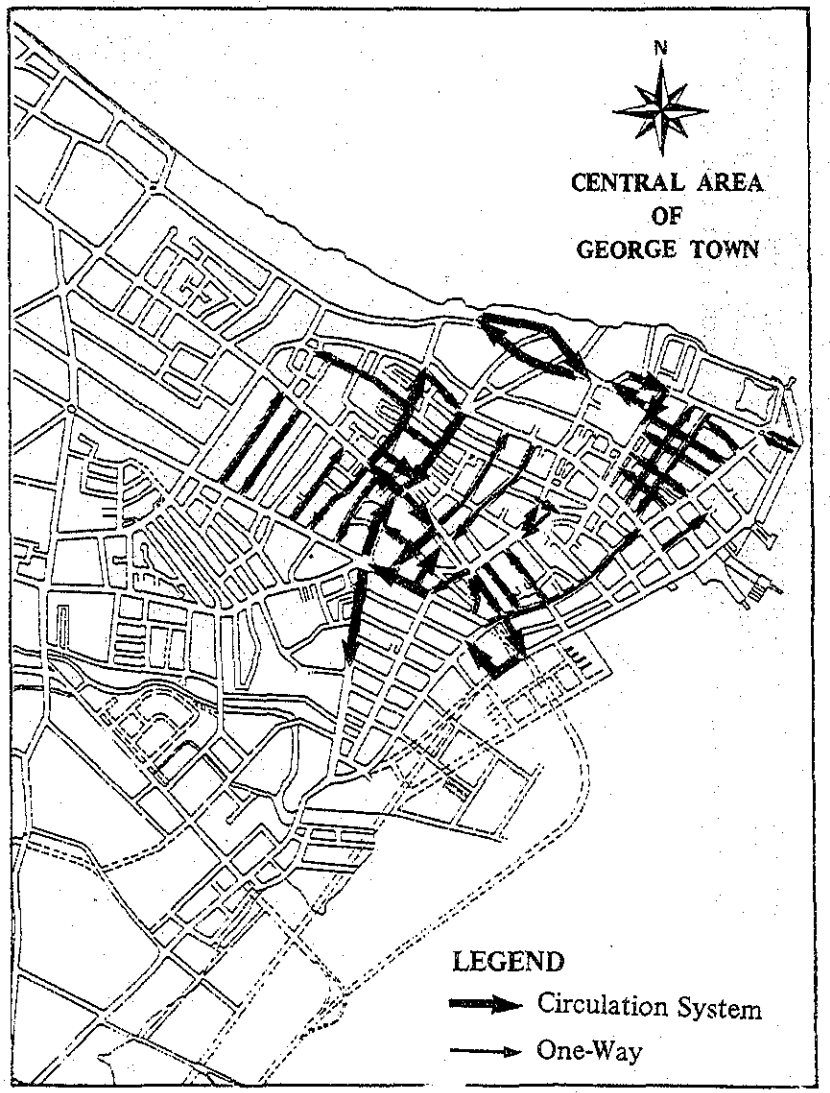


Figure 4.21 : Proposed Short Term Plan for Traffic Circulation System in Central Area

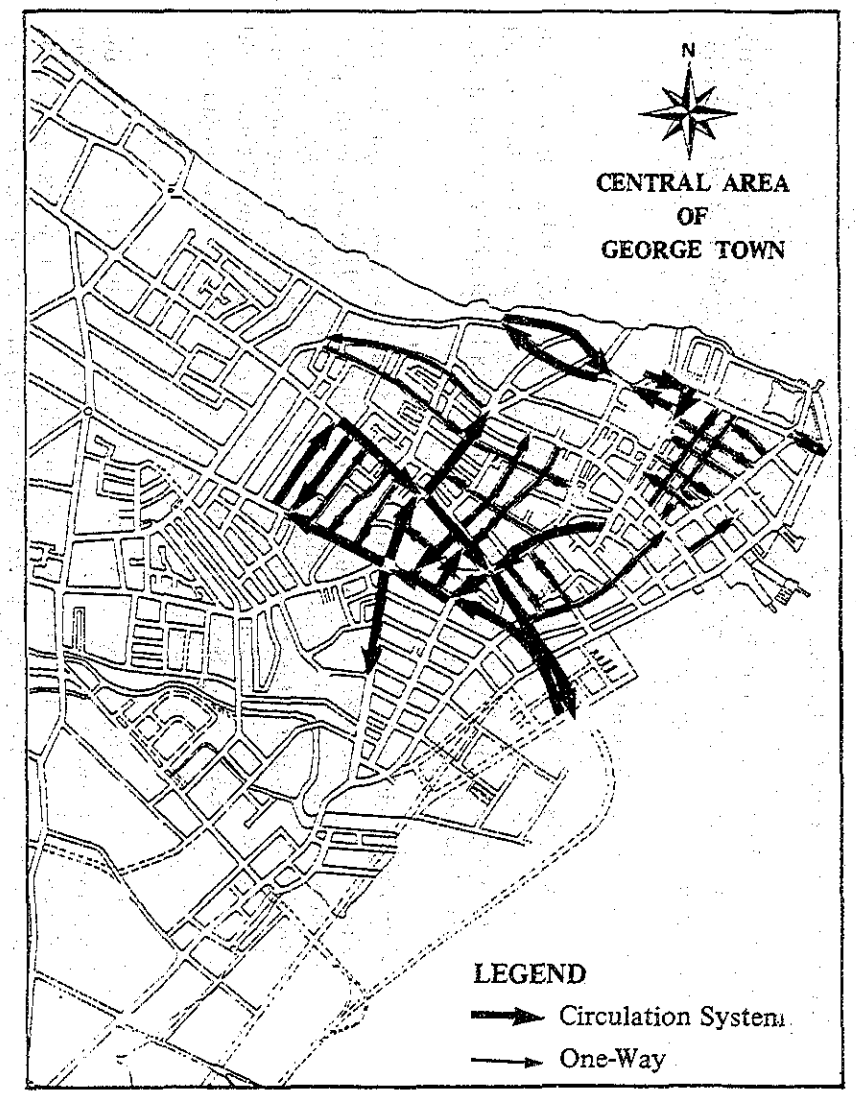


Figure 4.22 : Proposed Long Term Plan for Traffic Circulation System in Central Area

4.4.3 Bus Transport Improvement Plan

A bus-stop improvement plan and a bus terminal relocation plan for the Central Area are proposed in order to improve existing bus services in terms of amenities, dependability, and convenience.

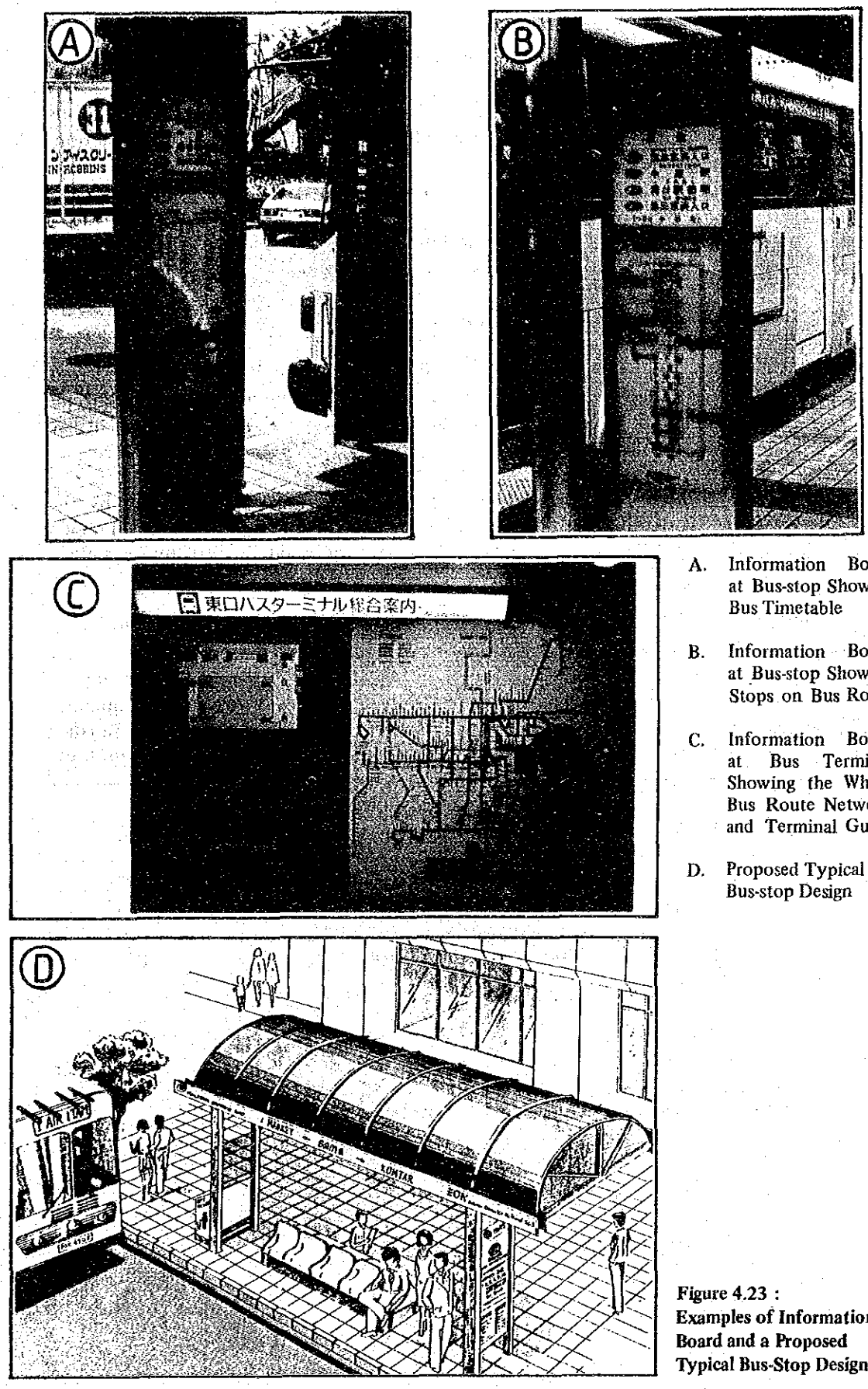
A. Bus-stop Improvement Plan

The upgrading of bus-stop facilities for the convenience and comfort of bus users is one of the most basic and important measures for the overall improvement of the level of bus service. Herein, a bus-stop improvement plan for the Central Area of George Town is presented.

More than 90 bus-stop locations in the Central Area require improvements such as provision of shelters, benches and information boards. However in this plan, the more needy cases were identified using the criteria of passenger volume, existing road and traffic conditions and also taking into consideration the future improvement plan for one-way circulation system. Thus, a total of 40 bus-stop locations have been identified for the implementation programme. The project's cost is estimated as about M$0.2 million.

However, the erection of bus shelters could be undertaken with the cooperation between the Municipality on one hand and sponsorship from bus companies, private enterprises and community service organizations on the other hand. Properly-designed bus shelters can also be integrated into the design of the pedestrian path network and the roadway beautification program.

Examples of information boards and a typical bus-stop design are presented in Figure 4.23. The important elements of the design are shelter, display information boards for time-table and route map, bench and dustbin.



A. Information Board at Bus-stop Showing Bus Timetable

B. Information Board at Bus-stop Showing Stops on Bus Route

C. Information Board at Bus Terminal Showing the Whole Bus Route Network and Terminal Guide

D. Proposed Typical Bus-stop Design

Figure 4.23 : Examples of Information Board and a Proposed Typical Bus-Stop Design

B. Prangin Bus Terminal Relocation Plan

In view of the impending construction of Coastal Road, the Prangin Bus Terminal must be relocated elsewhere to make way for the road construction.

1. Candidate sites for New Bus Terminal

Candidate sites for the new bus terminal (hereinafter called CBD Bus Terminal) are considered based on the following.

(1) Existing Bus Transport Facilities

Table 4.11 shows the utilization level of existing bus transport facilities. At the Prangin Bus Terminal there are twenty (20) berths and about nine thousand and one hundred (9,100) passengers utilize the bus terminal daily.

Based on this capacity, the necessary floor space required by the CBD Bus Terminal to accommodate the functions of the Prangin Bus Terminal must be at least five thousand (5,000) square meters.

Table 4.11 : Utilization Level of Bus Transport Facilities in the CBD of George Town, 1987

Bus Transport Facility	No. of Routes	No. of Trips (Arrival & Departures)	Daily Passenger Volume	No. of Berths	Existing Frequency Per Berth (Trip/day)
Jetty Bus Terminal	11 urban	1,380 * (690)	11,900	14	99 * (49)
Prangin Bus Terminal	17 regional	1,160 * (580)	9,100	20	58 * (29)
Komtar Bus Interchange	8 (6 urban & 2 regional)	700	5,700	8	88

Note : * Total of arrivals and departures.
Numerals inside ( ) indicate no. of departures.

(2) Bus Operation Pattern

In the existing bus operation pattern, the Prangin Bus Terminal being located near the Komtar Bus Interchange make it very easy for bus transfers. Urban and regional bus services are well connected. With the relocation of Prangin Bus Terminal, depending on the site of the new CBD Bus Terminal, three possible bus operation patterns could be considered. These alternatives are shown in Figure 4.24.

However, Alternative 3 cannot be recommended for the Study Area because it requires bus transfers, from urban bus to regional bus or vice versa and also from one region in the island to another, to be made at the Central Area.

Moreover, a bus terminal should be used by many passengers as the origin or destination point. Such a desirable bus operation pattern can only be achieved if the site for the CBD Bus Terminal is found within the Central Area.

(3) Basic Conditions for Candidate Site

Based on the preceding discussions in (1) and (2), the following are the basic conditions for a candidate site:

a. Must have a land area of more than 5,000 square meters

b. Must be located in the Central Area

c. Terminal facilities can either be for regional bus only (Independent Structure) or for both urban and regional buses (Integrated Structure).

d. Land must be easily available within a short time because of the urgency to relocate Prangin Bus Terminal.

(4) Candidate sites for CBD Bus Terminal

The following three (3) sites shown in Figure 4.25 have been found to meet the basic conditions for the CBD Bus Terminal, viz:

A. Near Ferry Terminal on land belonging to Penang Port Commission.

B. On land to be reclaimed near the entrance of Coastal Road.

C. On MPPP's land earmarked for development

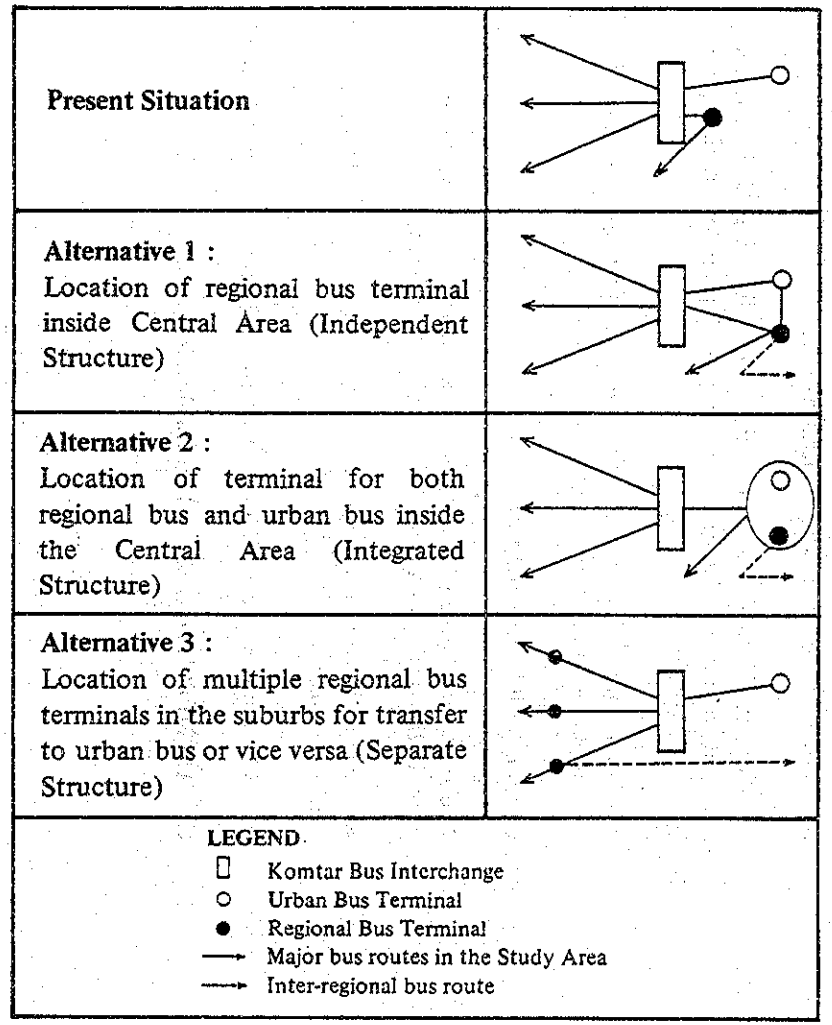


Figure 4.24 : Alternative Plans for Bus Operation Pattern

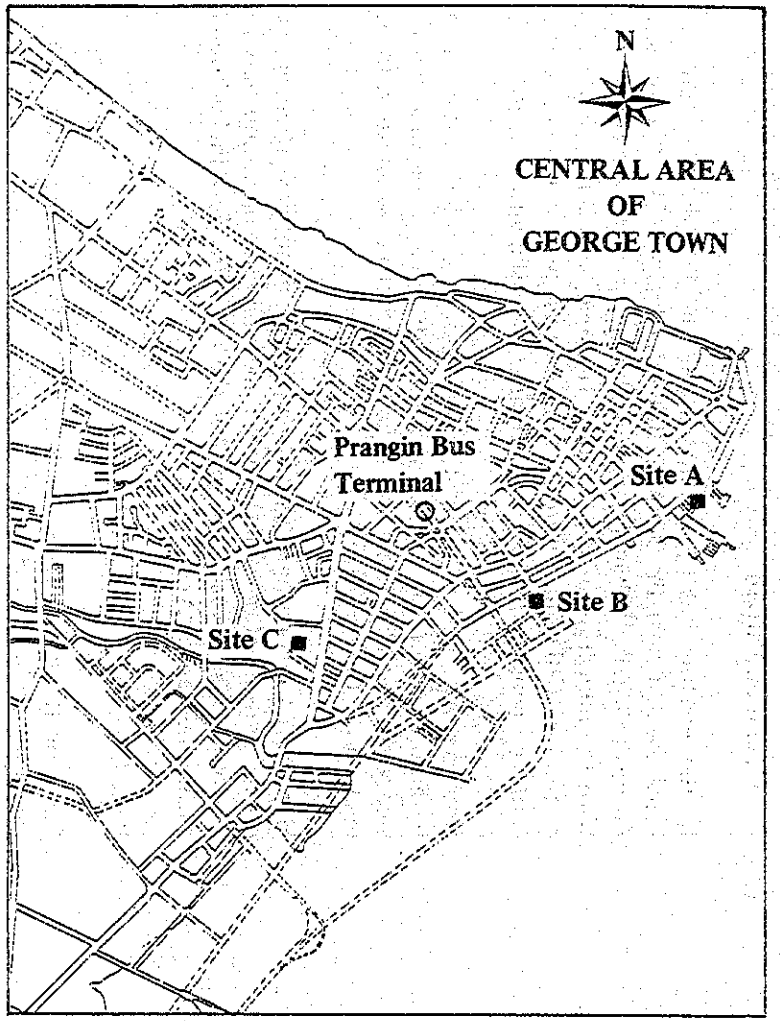


Figure 4.25 : Candidate Sites for Relocation of Prangin Bus Terminal

2. Present Bus Usage Pattern

From the result of the Bus Ridership Survey conducted by the Study Team, the present bus usage pattern (for both urban and regional bus) can be illustrated as shown in Figure 4.26 and following observations are made.

(1) Boarding and alighting by passengers within the Central Area are concentrated around KOMTAR area and the Ferry Terminal area.

(2) Present volume of bus users around KOMTAR only and Ferry Terminal only are about similar, i.e. about 22,000 persons daily.

(3) If the surrounding catchment area is included then the Komtar area distinctly shows a larger volume. This reflects the movement of the city's central point towards the direction of KOMTAR.

(4) Considering the future growth of this City the future volume of bus users around the KOMTAR area can be expected to increase further. As for the Ferry Terminal area it would depend very much on the ferry passenger volume itself. And the future volume of ferry passenger could not be expected to increase sharply, rather it is expected that the present volume would be maintained.

3. Screening of Candidate Site

(1) Necessary functions of a regional bus terminal

Generally, in order to establish an organized passenger transportation system in a city, the roles of a regional bus terminal would include the following basic functions, viz:

a. Serves as the arrival and departure point for regional and inter-regional bus passengers.

b. Serves as the point for transfer to other buses or other transport modes.

c. Serves as one of the cores in shaping the urban structure.

It is obvious that a bus terminal is a facility for bus users and it is therefore desirable that many people will utilize it and in the process the area around the terminal will transform into a new urban core.

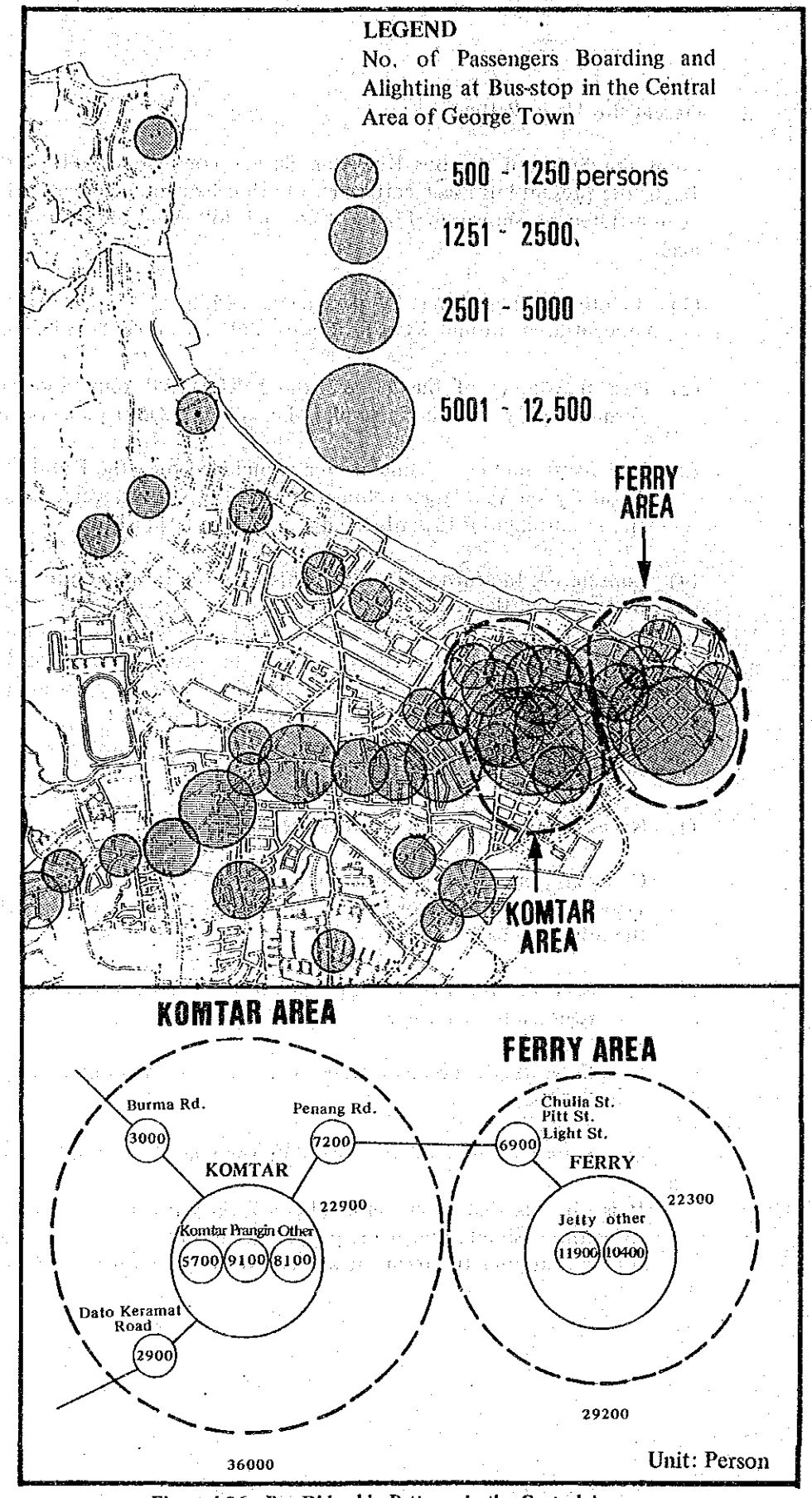


Figure 4.26 : Bus Ridership Pattern in the Central Area

On the other hand, one of the functions of a bus terminal is also to provide the place for readjustment of bus schedules. But this is more of the function of a bus depot.

In principle, the characteristics of a terminal for passengers is different from a depot for buses. The former should be located in the Central Area where there is much human activities, while for the latter the availability of cheap land is more important.

Therefore in relocating the Prangin Bus Terminal, the site for CBD Bus terminal will be determined by its capability to fulfill the above-mentioned three basic functions of a terminal.

(2) Operational Functions of Regional Bus Services

The following operational functions for regional and inter-regional bus services are necessary:

* High Travel Speed

  Compare to urban buses, regional buses serve mostly intermediate to long distance travel and hence a higher travel speed is expected.

* Reliability

  The frequency of most regional bus services is smaller than urban bus services. As a result, the reliability of regional bus services is higher.

* Trunk Road Operation

  Most regional buses operate along major trunk roads.

To meet these requirements, the following points have to be carefully considered when designating regional bus routes.

a. Avoid narrow urban streets having frequent traffic congestion and those where large buses will face difficulties in manouevering in and out of the bus stops.

b. The operation routes should be made easily comprehensible even to visitors.

(3) Evaluation of Candidate Sites

The three candidate sites for the regional bus terminal were evaluated from the perspective of the requirements of regional bus services and routing as described above. The evaluation is summarised in Table 4.12. Figure 4.27 (1) and (2) illustrate the access and egress of the candidate sites from KOMTAR area and Ferry Terminal as well as the possible access bus routes to each site.

The above evaluation clearly indicates that Site B is the most advantageous site for the purposed regional terminal. Furthermore, Site B is more superior if the future development of KOMTAR and its surrounding areas is taken into account. Site B is close to such city centre point and hence is more convenient to use.

Table 4.12 : Evaluation of Candidate Sites on Their Terminal Functions and Bus Routing

Function/ Conditions		Site A	Site B	Site C
Bus Terminal Functions	a. Boarding/ Alighting	Inconvenient to use for the larger volume of users from KOMTAR area △	Easy access to users from KOMTAR area, Users from Ferry Terminal will require bus transfer ○	Accessible to users from KOMTAR area but those from Ferry Terminal will require bus transfer △
	b. Transfer	Possible transfers between Ferry and Regional buses as well between urban and regional buses ○	Transfer between urban and regional buses possible pending on changes to urban bus routes or by walking. Transfer from Ferry to regional buses require a 700 m walk △	Transfer between urban and regional buses possible pending on changes to urban bus routes. Direct transfer from Ferry to regional terminal not possible △
	c. Future development Prospect	Absent of any urban development plan △	Coastal Land reclamation development area ○	Urban redevelopment area ○
Bus Route Operating Condition	a. Extent of Trunk Road Operation	Compete with urban bus routes and problem in passing through the congested Perak Road ×	Possible to run on all trunk roads ○	Part of the routes has to run on minor urban streets △
	b. Simplicity in routing	Complex ×	Simple ○	Complex ×

Note:

○ Slightly better than or equal to the present situation
△ Slightly worse than present situation
× Worse than present situation

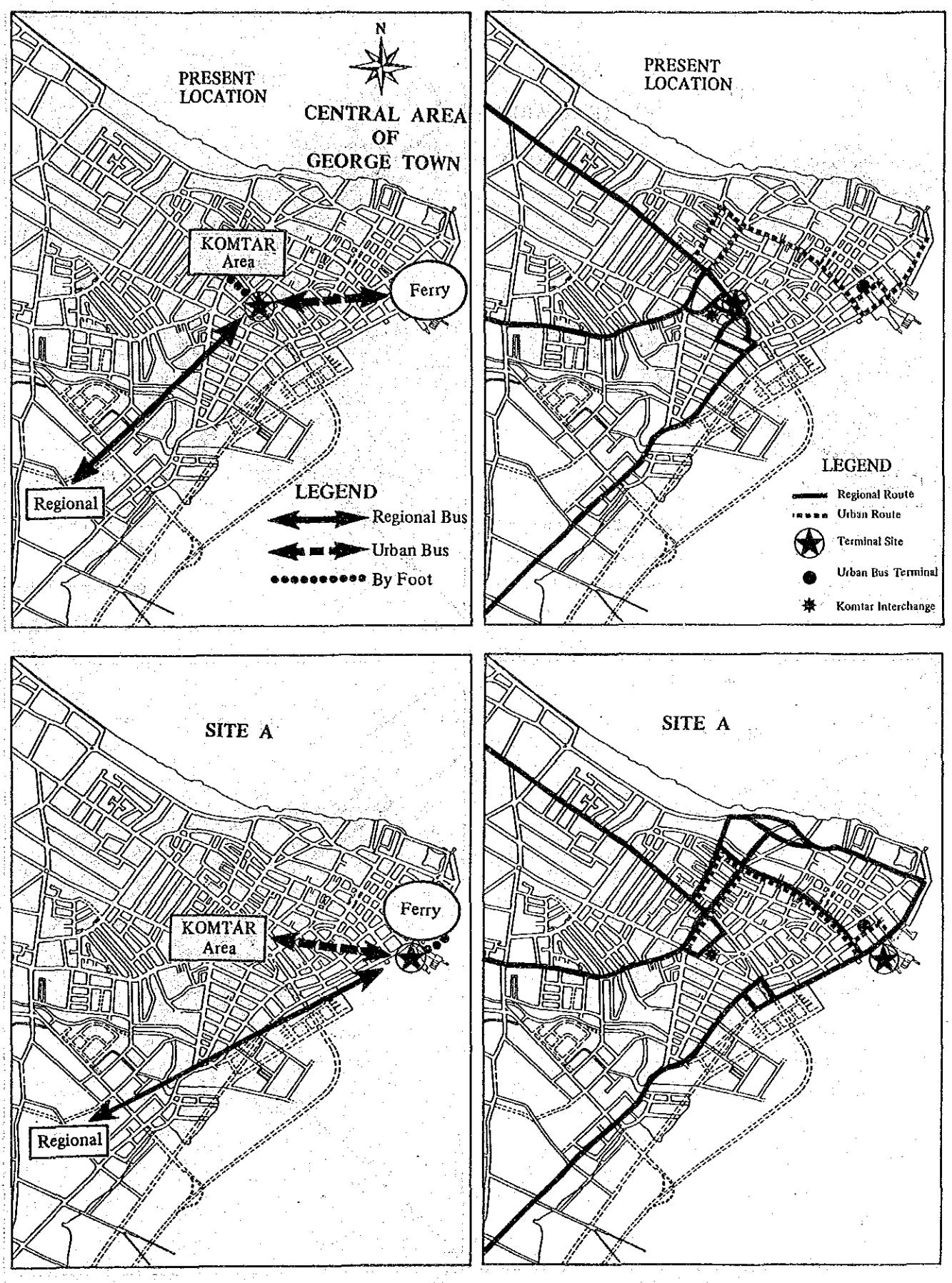


Figure 4.27 (1) : Access/Egress Modes to Bus Terminal at Each Candidate Site and its Bus Routing

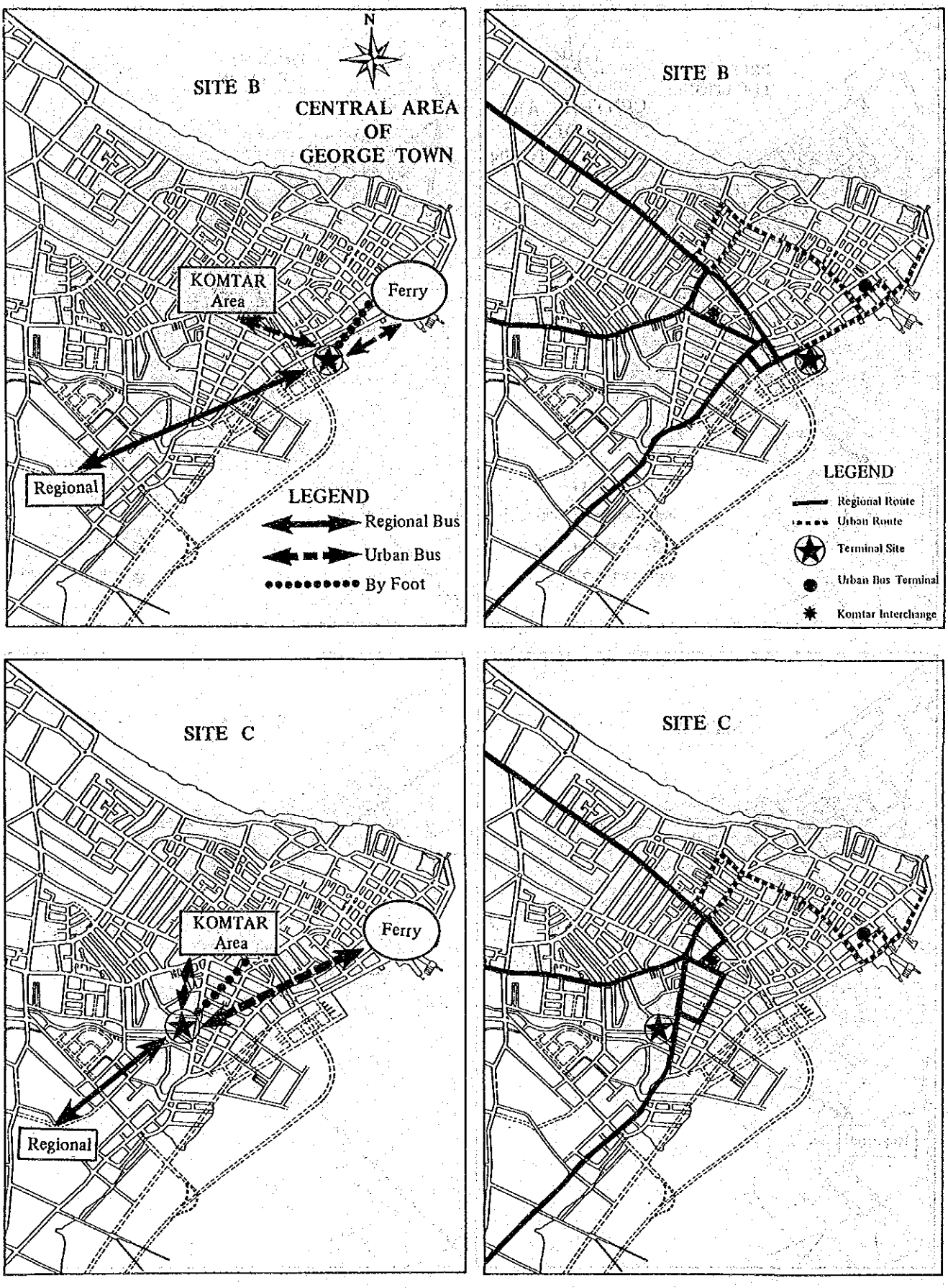


Figure 4.27 (2) : Access/Egress Modes to Bus Terminal at Each Candidate Site and its Bus Routing

(4) Conclusion

The conclusions for the site of the new regional bus terminal are as below:

a. In terms of convenience to users and future development prospects, it is proposed to construct a regional bus terminal only (Independant Structure) on Site B.

b. Site B will require land reclamation and thus must be constructed in conjunction with the construction of the North Coastal Road.

c. From the standpoints of financial aspect of the bus terminal and the mitigation of parking space shortage in the KOMTAR area, it will be necessary to construct car parking facilities when the CBD Bus Terminal is located on Site B.

It is contended that even with the construction of the proposed CBD Bus Terminal, the Jetty Bus Terminal still has the location that is most strategic as an urban bus terminal to the bus users from and around the Ferry Terminal. The possibility of having separate bus terminals for the regional and urban bus services in future therefore should be carefully studied in the proposed Bus Transport Masterplan Study.

Figure 4.28 shows the proposed bus operation pattern in the Central Area when the CBD Bus Terminal is located on Site B.

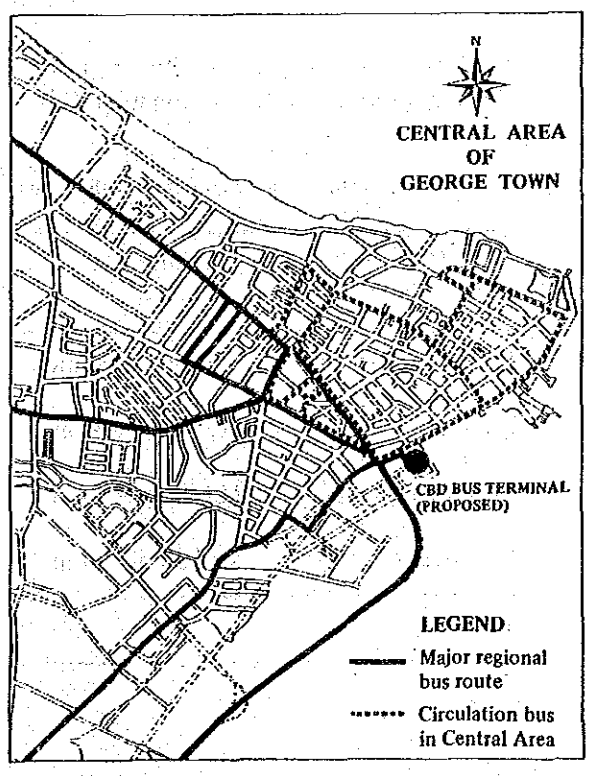


Figure 4.28 : Concept of Reorganized Bus Route Network in Central Area

4. Required Space for CBD Bus Terminal

In the future, because of the vivacity of urban activities in the Central Area and the dispersal of population to the suburbs, the share of bus usage to the overall traffic demand could well become lower. However, in terms of traffic volume, the existing bus passenger volume could be maintained.

On the other hand, an increase of 1.5% per annum for bus passenger volume could be expected because bus riderships will be induced by the implementation of various measures in the proposed Bus Improvement Plan and also because of the anticipated shift from private vehicles to public transport through a parking control plan.

Based on the estimated future demand, the necessary total floor area required in the new CBD Bus Terminal is about sixteen thousand (16,000) square meters consisting of the floor plans given in Table 4.13.

Table 4.13 : Floor Plans of Proposed CBD Bus Terminal

Terminal Level	600 sq.m
Concourse Level (1st floor)	2,500 sq.m
Car Park (1st and 2nd floor)	7,500 sq.m
Total	16,000 sq.m

Thus the construction of the proposed CBD Bus Terminal will require M$7.35 million. A breakdown of this amount is shown in Table 4.14.

Table 4.14 : Estimated Project Cost for CBD Bus Terminal

Item	Unit Cost	Quantity (sq. m.)	Cost (M$ million)
Land Acquisition	M$300 per sq.m	6,000	1.80
Building	M$500 per sq.m	10,000	5.00
Terminal Level	M$ 80 per sq.m	6,000	0.48
Pedestrian Bridge	M$100 per sq.m	710	0.07
Total			7.35

4.4.4 Pedestrian Path Network Plan

The installation of a pedestrian path network in the city enhances pedestrians' safety and provides amenities for walking. As a result, it is possible to ensure traffic safety and mobility in the city.

Already the MPPP had installed pedestrian paths here and there in a piecemeal manner. It is proposed that the installation of pedestrian paths to be conducted earnestly and in a coordinated manner in order to develop a pedestrian path network for the Central Area.

A. Pedestrian Path Network Plan

Figure 4.29 shows a desirable pedestrian path network plan installed around the 'Pedestrians and Vehicles Segregation Axis' and the 'Pedestrian Path Axis' established from the expansion of the urban shape of the Central Area.

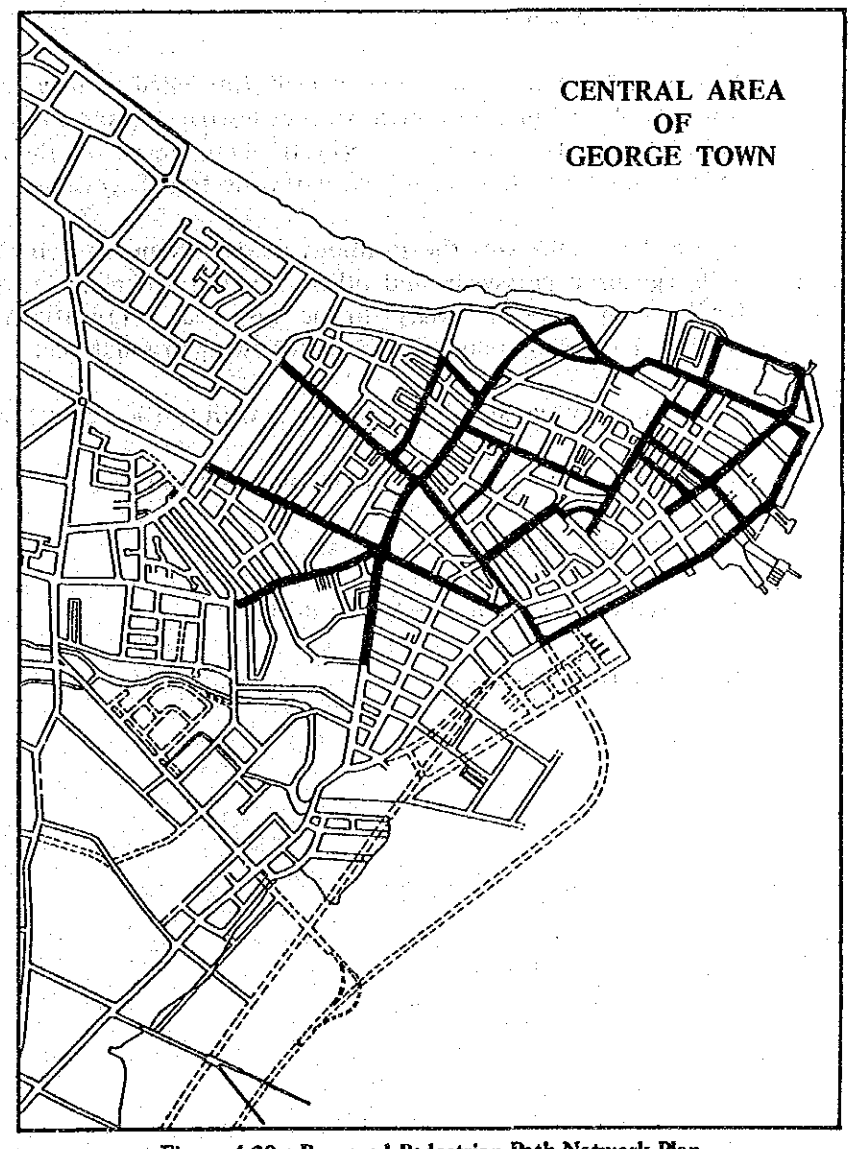


Figure 4.29 : Proposed Pedestrian Path Network Plan

1. Types of sidewalk in Pedestrian Network

Types of sidewalk proposed for the network are illustrated in Figure 4.30. The network is composed primarily of landscaped pavement. However, a pedestrian mall is proposed along the stretch of Maxwell Road (between Penang Road and Prangin Road) to accommodate an increasing urban pedestrian demand. One other suitable site is Pitt Street (between Stewart Lane and Buckingham Street). The relatively heavy pedestrian movement and the site spatial conditions warrant their considerations. On the other hand, Armenian Street and Cannon Street would be suitable for conversion into community streets. Reasons are attributed to their low volume traffic roadway and as a gateway to the buildings of architectural and historical importance in the vicinity.

Typical plans of pedestrian mall and community street on Pitt Street and its periphery are shown in Figure 4.31.

2. Pedestrian Crossing Facilities

At busy intersections and along heavily trafficked roads where there are conflicts of vehicular movement with pedestrian movement, it is necessary to install priority measures for pedestrian crossings from the viewpoint of pedestrian safety and the continuity of pedestrian accessibility.

Figure 4.32 illustrates the locations in the urban area already installed with signalized crosswalk and other locations where pedestrian crossing facilities are also necessary to be installed. Priority measures for pedestrian crossings may include the following installations:

a. pedestrian signals which coordinate with traffic control signals

b. push-button type signals or yellow flashing light

c. zebra-crossings

d. overhead pedestrian bridges or decks

e. subway crossings

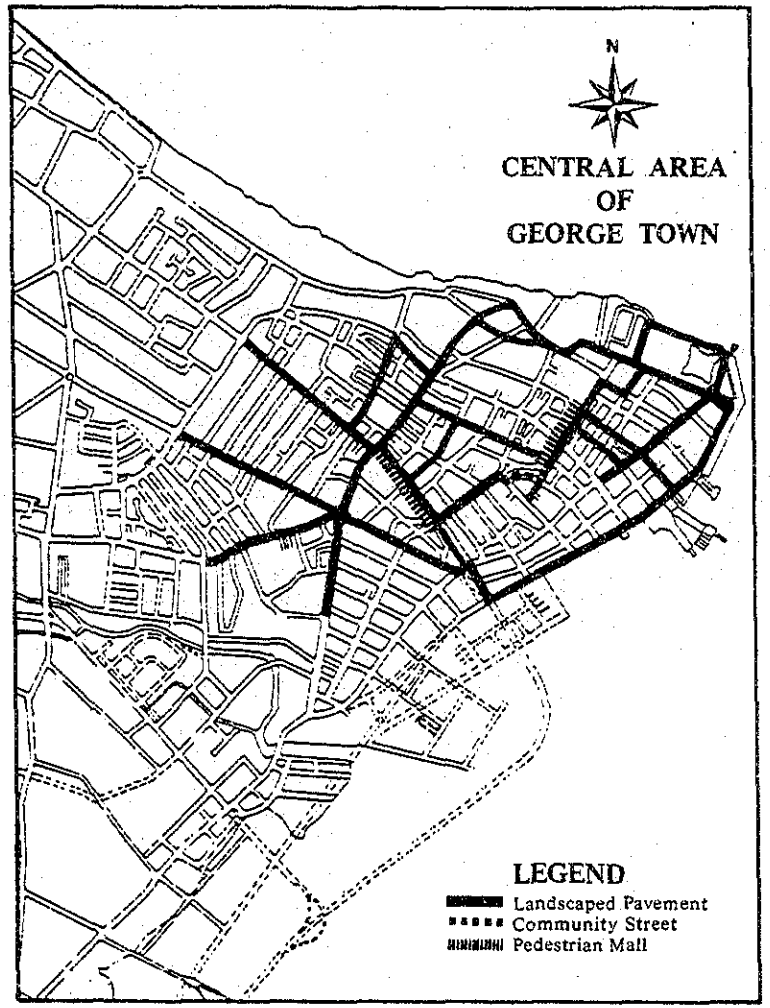


Figure 4.30 : Types Of Pedestrian Sidewalk In The Network

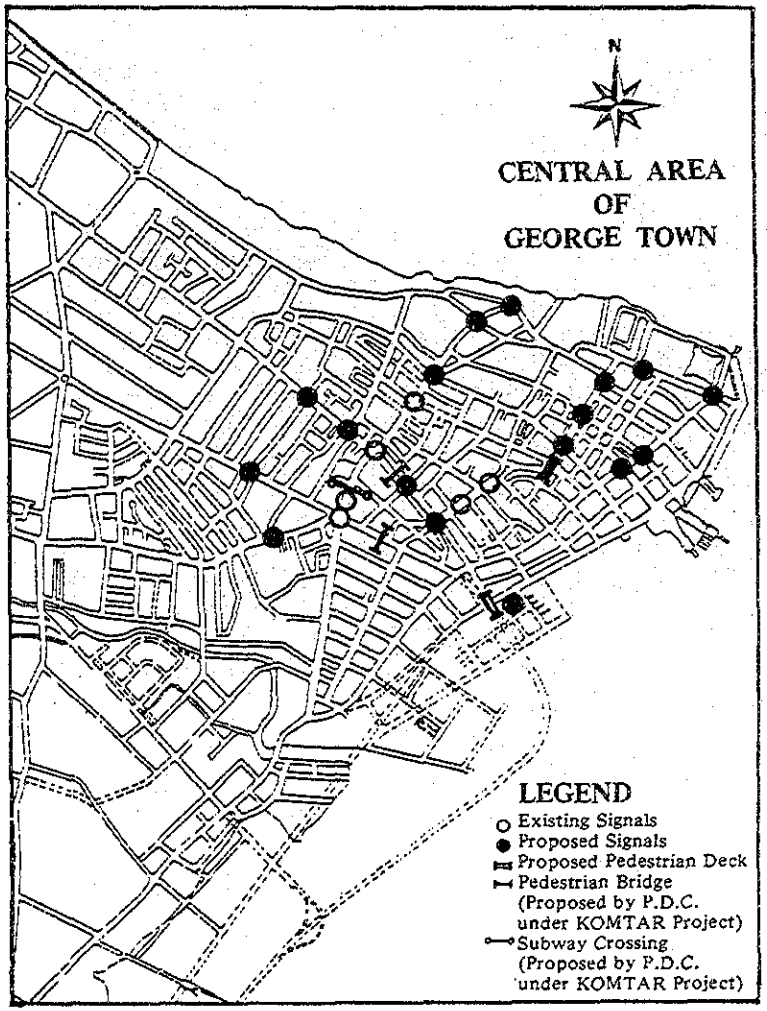
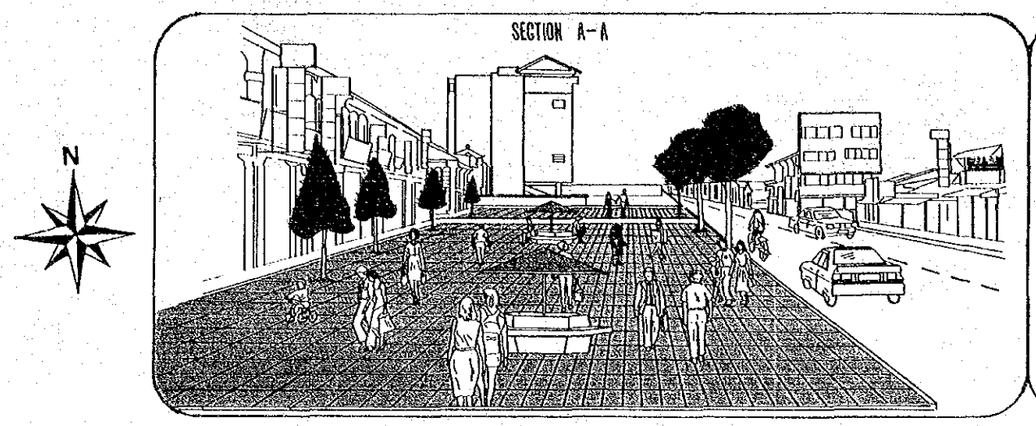
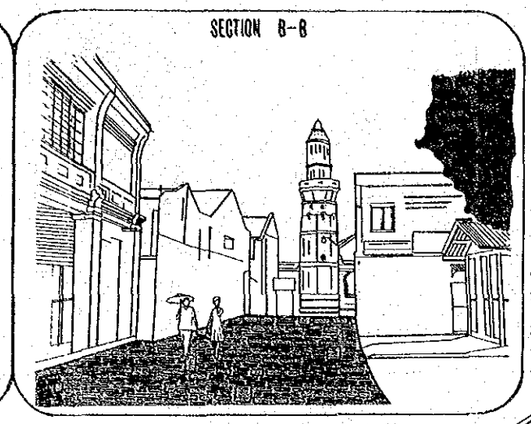


Figure 4.32 : Locations Installed With Pedestrian Crossing Facilities



Pedestrian Mall



Community Street

Figure 4.31 : Pedestrianisation Improvement Plan Along Pitt St. And Its Periphery (Pedestrian Mall & Community Street)

B. Sidewalk Width and Amenities

Conceptuually, the planning aspects of the pedestrian path take into consideration the sidewalk width and the pedestrianisation improvement measures.

1. Sidewalk Width

A pedestrian sidewalk width takes into consideration the number of lanes for carriageway and waiting/parking lane width (see Figure 4.33).

a. Carriageway Width

The overall carriageway width is determined by the number of traffic lanes required on a particular roadway. Determination is made by estimating the traffic volume demand by the year 2000. Generally, each traffic lane is designed for 3.25m wide. However, for a one-way street the overall carriageway width is taken as 6.0m. Nevertheless, the specifications may be varied according to site conditions.

b. Waiting/Parking Lane Width

The allocation of a waiting/parking lane for a particular roadway is based largely on the existing site conditions. Basically, a waiting lane width is 1.5m and the parking lane at 2.0m.

Consequently, the sidewalk width could only be decided after having pre-determined the carriageway and waiting/parking lane width. Generally, a minimum sidewalk width of 1.50 m is desirable in allowing a conducive and pleasant pedestrian movement. And the height of the sidewalk kerb (kerbstone) from the adjoining carriageway would be between 150mm and 225mm.

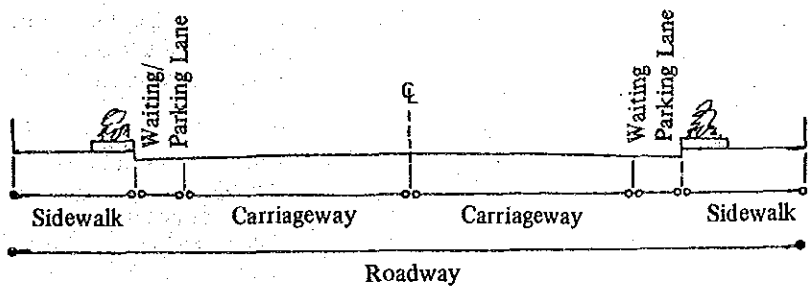


Figure 4.33 : Typical Cross-Section Of A Roadway

2. Pedestrianisation Amenities

Careful and sensitive approach to design and co-ordinated planning of pedestrianisation amenities would add immesurably to the quality of the urban townscape. Table 4.15 illustrates a list of the basic pedestrianisation amenities and their respective features. Illustrations of the street furnitures are presented in Figure 4.34.

Table 4.15 : Basic Pedestrianisation Amenities

	Basic Amenities		Features
1.	Street Furniture		
	a.	Trash Receptacle	. To maintain cleaniness of urban scenes . To instil civic consciousness on public environment
	b.	Planting Boxes	. Beautification of urban scenes . Add colour and vista to streets . To segregate between carriageway and sidewalk . Easy installation and removal
	c.	Special Street Lightings	. Add unique character to streets and pedestrian precincts; recommended for pedestrian mall and community street . Enhance pedestrian safety
	d.	Directional Street Signs	. Clear directional guidance located mainly at intersections indicating area names, buildings and public services served . Facilitate traffic flow . Provide efficient, attractive indication especially at busy intersections
	e.	City Information Panels	. Provide directional guidance to the urban city landmarks . Serve as a means of effective communication in the urban area
	f.	Benches	. Provide the people a low-cost leisure facilities . Allow the people to enjoy the street panaromic view
2.	Sidewalk Paving Blocks		
	a.	Concrete Blocks	. Requiring negligible maintenance . Durable and safe surface . Low-cost paving blocks
	b.	Interlocking Block	. Brighten up the outdoor environment with their subtle colours and textures . Durable and safe surface that is non-slip ensuring safety for pedestrians . Colour coding can be used to delineate separate areas . Easy access to underground utility services . Allow complete freedom and flexibility in paving curves, corners, or borders
3.	Greenery Amenities		. Patches of greeneries, and wherever possible, individual trees would add colour and beauty to the city
4.	Public Utilities		. Provides easy accessibility and convenience to the public

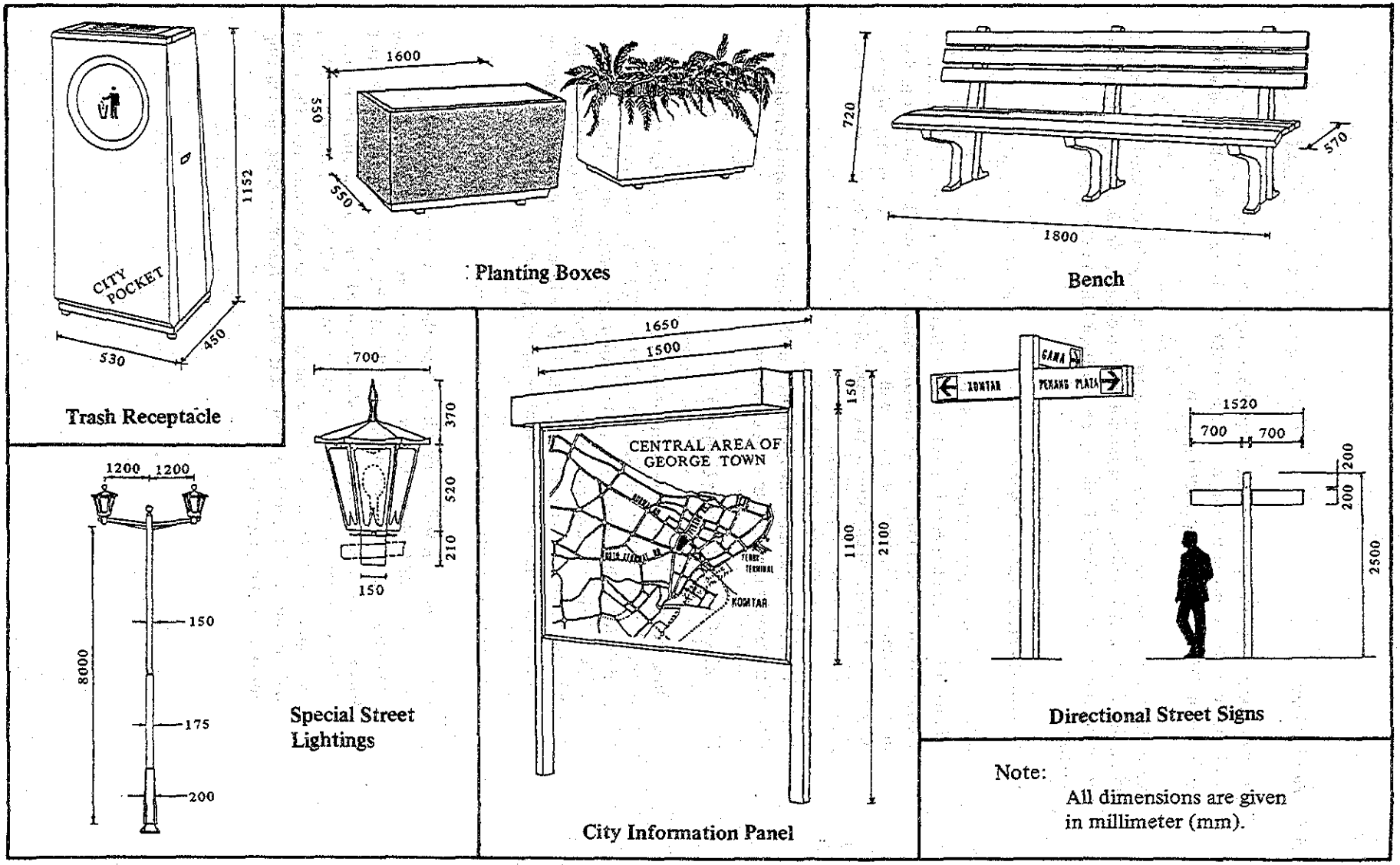


Figure 4.34 : Illustrative Concept Of The Street Furnitures Proposed For The Pedestrian Network

4.4.5 Parking Plan

It is necessary to strengthen on-street parking control on primary and secondary roads in order to secure sufficient road space not only for the traffic demand within the Central Area but also for pedestrian paths.

Nevertheless, it is not necessarily desirable to exclude vehicular traffic movement from the Central Area from the standpoint of economic development. Therefore the construction of parking facilities by both public and private sectors is also proposed.

A. On-Street Parking Control Plans

The criteria for on-street parking control are traffic volume on road section and its functional classification. On-street parking would be prohibited on road section wherever warranted by the traffic volume. Basically, on-street parking on a primary or secondary road will be prohibited. However, single-side parking will be allowed only if the road width is permissible and necessary from the landuse considerations.

Two (2) on-street parking control plans for the Central Area are formulated in view of increasing the existing road capacity.

1. Parking Control Plan in year 1990

   On-street parking will be prohibited on the primary roads and those roads forming the circulation system in the CBD. Furthermore, from the standpoint of bus routes and pedestrian paths, single-side parking on other roads will be allowed only when road space is sufficiently wide enough. Therefore, this parking control plan will reduce the number of existing on-street parking lots by about nine hundred (900).

2. Parking Control Plan for year 2000

   On-street parking will be prohibited on the primary and secondary roads and those roads forming the circulation system in the CBD. The prohibition of on-street parking will also be extended to the district roads. Furthermore, from the standpoint of bus routes and pedestrian pathways, single-side parking on other roads will be allowed only when road space is sufficiently wide enough. Therefore, about one thousand and six hundred (1,600) parking lots will be removed from the existing on-street parking facilities.

B. Parking Facility Construction Plan

The future shortage of parking space may be mitigated by employing the following two (2) tactics.

(1) To increase the use of public transport.

This tactic calls for an all-out improvement of public transport services to attract more people to use public transport instead of car. Hence, parking demand could be reduced.

(2) To encourage privatisation of parking supply

The private sector should be encouraged to build and operate parking facilities. Besides the creation of more employment, this tactic could reduce public expenditure on new construction of parking buildings.

In order to make the implementation of these two (2) tactics successful, it is proposed that public parking facilities be provided to counterbalance the parking space supply reduced by the enforcement of the on-street parking control plan.

Therefore, taking into considerations the one thousand six hundred (1,600) lots to be reduced under the Parking Control Plan for year 2000 and the huge shortage of parking space, it is necessary to plan for the provision of about two thousand (2,000) lots by the year 2000. Based on the demand forecasted earlier, during the period 1991 to 1995, spaces for about six hundred (600) parking lots would be required first. Considering the availability of urban space and the scale of existing parking facilities, these will be provided by the construction of two (2) medium-scale public parking buildings in the CBD where parking demand will be highest. During the period 1996 to 2000, spaces for one thousand and four hundred (1,400) more parking lots will be provided at three (3) other locations in the Central Area.

The proposed five (5) sites for public parking buildings are listed as below and indicated on Figure 4.35.

(1) On the site of the existing market at Penang Road

(2) The site of the proposed CBD Bus Terminal

(3) On the site of existing car park at Downing Street

(4) On the site near Amoy Lane/Hutton Lane

(5) On redeveloped land near Brick Kiln Road

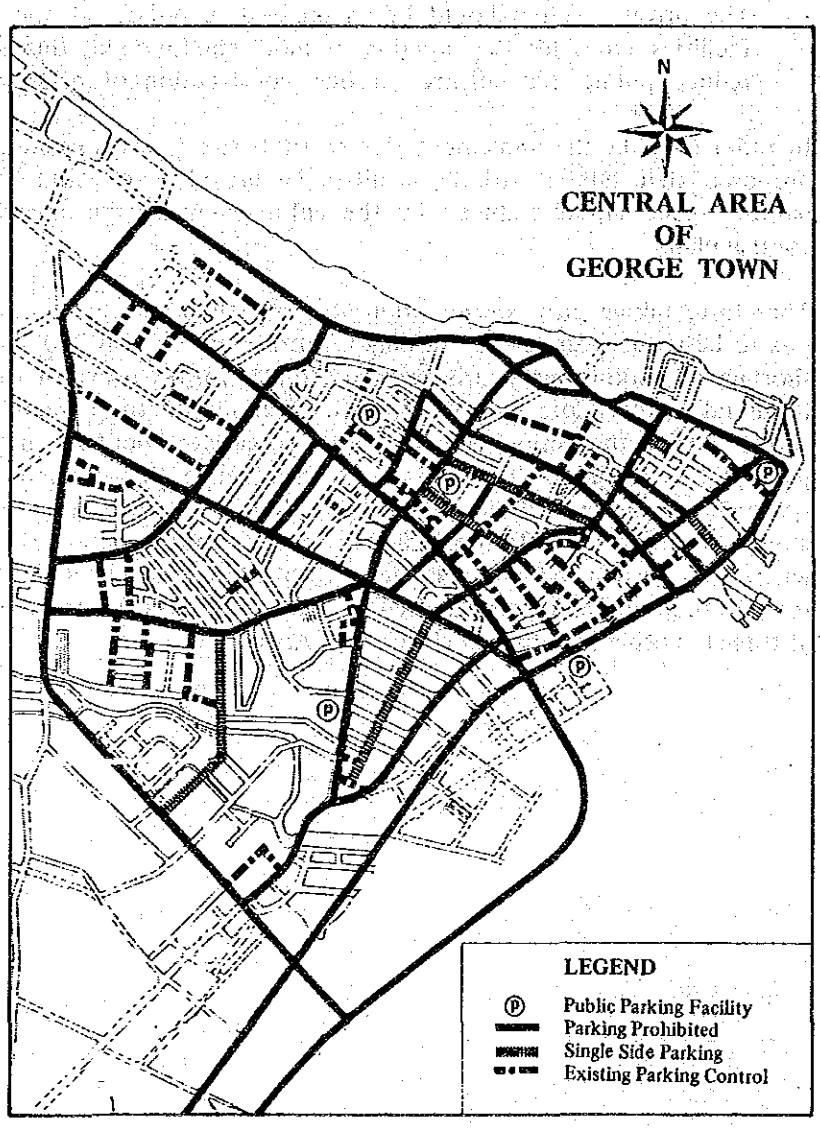


Figure 4.35 : Proposed Parking Plan In The Central Area