5.1.2 Conversion From Peak Hour Delay Time to Annual Delay Time

A. Daily Delay Time

The daily delay time is defined as the total delay time resulting from travel made by vehicles from 8:00 to 18:00 hour. This can be calculated by knowing the one hour delay time in morning peak, evening peak and off-peak. Furthermore, a relationship between peak hour and off-peak hour delay time can be obtained from the observed data at various intersections. Figure 5.1.3 shows an example from which the following equation is obtained, that is

$$Do = 0.75\,(Dm + De)/2$$

where:

Do : off-peak hour delay time
Dm : morning peak hour delay time
De : evening peak hour delay time

Calculations performed at other intersections also produced rather similar result.

Therefore, the daily delay time can also be calculated as follows:

$$\begin{aligned}\text{Daily Delay Time} &= Dm + 8\,Do + De \\ &= 4(Dm + De)\end{aligned}$$

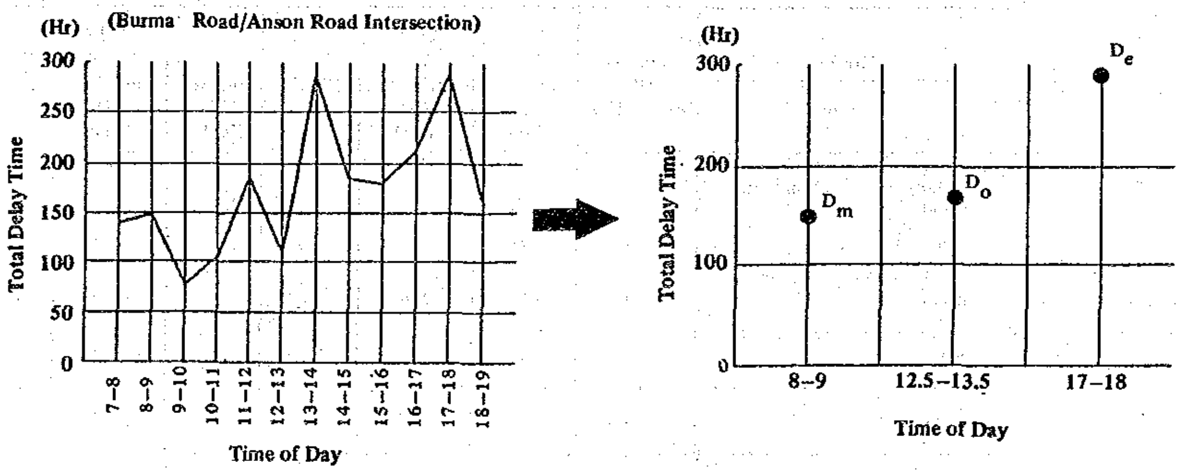


Figure 5.1.3 : Fluctuation Of Total Delay Time During 7:00 – 19:00 Hour

B. Annual Delay Time

The number of effective days in a year is taken as 250 days having subtracted all the Saturdays, Sundays and holidays from the total number of days in a year.

5.1.3 Estimated Difference in Delay Time

The annual delay time for forty-five (45) intersections in the Study Area are computed for the existing and future traffic conditions in simulations with and without TSCS. The difference in delay time are then estimated.

For the existing traffic condition, the TSCS could be expected to reduce annual delay time by about 1.4 million hours or 23% down from an annual delay time of more than 6 million hours without the TSCS. In the future traffic condition (1990) with the TSCS, a reduction of about 1.7 million hours from 10.7 million hours without TSCS could be expected. This is a reduction of 16%.

Similarly, in 1994 a reduction of about 2.3 million hours from 16.0 million hours without TSCS could be expected. This is a reduction of 14%.

Table 5.1.4 shows the annual delay time which has been estimated from simulations under existing traffic condition (1986) and future traffic conditions in 1990 and 1994.

Table 5.1.4 : Estimated Annual Delay Time Difference

(Unit : 1,000 hrs.)

	Existing Traffic Condition (1986)			Future Traffic Condition (1990)			Future Traffic Condition (1994)		
	Without TSCS (A)	With TSCS (B)	Difference (A)–(B)	Without TSCS (A)	With TSCS (B)	Difference (A)–(B)	Without TSCS (A)	With TSCS (B)	Difference (A)–(B)
Annual Delay Time for 45 intersections	6,075	4,652	1,423	10,683	8,954	1,728	16,021	13,704	2,317
Annual Delay Time per Intersections	135	103	32 (0.23)	237*	199*	38 (0.16)	356*	305*	51 (0.14)

Note : Numericals inside ( ) on last row refer to reduction ratio

*The estimate of delay time per intersection is on the high side because the 45 intersections included in the simulation consist of mostly critical intersections. As the TSCS is further expanded in future, the average delay time per intersection should become smaller because the other less critical intersections are being included.

5.1.4 Benefit According To Staging Plan

A. Staging Plan

The construction period for a staging plan is established as follows :

		Construction Year	Number of Intersection Newly Constructed/ To Be Constructed
STAGE I	:	1986	16
STAGE II	:	1990	49 (65)
STAGE III (Host Computer)	:	1994	59 (124)
STAGE IV (Sub-station)	:	1997	25 (149)

Note : ( ) indicates cumulative number at each stage.

The implementation of Stage II is assumed to begin in 1990. In other words, the Staging Plan consists of constructing forty-nine (49) computerised intersections under Stage II in 1990, introduces a Host Computer, and constructing fifty-nine (59) intersections under Stage III in 1994. However, the construction of Bayan Lepas sub-station and twenty-five (25) intersections under Stage IV will only start in 1997.

B. Delay Time According to Staging Plan

Based on the above result, the annual delay time according to the Staging Plan is calculated and presented in Table 5.1.5.

Table 5.1.5 : Delay Time according to the Staging Plan

Year	Staging Plan			Annual Delay (1000 hrs)		
	Construction		No. of Intersection	Without TSCS	With TSCS	Difference
1986	STAGE I	(16)	–	–	–	–
1987			16	3,184	2,384	800
1988			16	3,760	2,880	800
1989			16	4,436	3,479	957
1990	STAGE II	(49)	16	5,234	4,203	1,031
1991			65	15,561	13,297	2,264
1992			65	17,415	15,111	2,304
1993			65	19,489	17,172	2,317
1994	STAGE III	(59)	65	21,811	19,514	2,297
1995			124	40,789	36,647	4,142
1996			124	44,655	40,384	4,271
1997	STAGE IV	(25)	124	48,888	44,502	4,386
1998			149	60,355	55,664	4,691
1999			149	63,985	59,294	4,691
2000			149	67,599	62,908	4,691

C. Benefit According to Staging Plan

1. Monetary Conversion

The transport cost due to delay time can be measured using the time value for vehicle user and the cost of fuel consumption only when vehicle is idling.

The time values for car user and motorcycle user are M$4.57 and M$1.28 per vehicle hour respectively.* Based on the composition ratio of car to motorcycle in the Study Area, the weighted time cost in the Study Area is estimated as M$3.80 per PCU hour.

Fuel cost is estimated as follows : The fuel consumption when idling is assumed to be 0.6 litre/hr**. Since the cost of gasoline in Penang Island is M$0.93 per litre, the fuel cost is obtained as M$0.57 per PCU hour.

2. Benefit Estimate for the TSCS

The benefit derived by computerization of signalized intersections can be measured by the difference in transportation cost due to delay time according to the staging plan.

Table 5.1.6 shows the benefit of computerization for the staging plan.

---

* Source : Klang Valley Transportation Study 1986
** Source : Association of Traffic Control Facility, Japan.

Table 5.1.6 : Yearly Benefit

(M$ million)

Year	Staging Plan: Construction	Staging Plan: No. of Intersection	Annual Transport Cost: Without TSCS	Annual Transport Cost: With TSCS	Annual Transport Cost: Difference (Benefit)	Benefit excluding Stage I
1986	STAGE I (16)	–	–	–	–	–
1987		16	13.9	10.4	3.5	–
1988		16	16.4	12.6	3.8	–
1989		16	19.4	15.2	4.2	–
1990	STAGE II (49)	16	22.9	18.4	4.5	–
1991		65	68.0	58.1	9.9	4.7
1992		65	76.1	66.0	10.1	4.9
1993		65	85.2	75.0	10.1	4.9
1994	STAGE III (59)	65	95.3	85.3	10.0	4.8
1995		124	178.2	160.1	18.1	12.9
1996		124	195.1	176.5	18.7	13.5
1997	STAGE IV (25)	124	213.6	194.5	19.2	13.9
1998		149	263.8	243.3	20.5	15.3
1999		149	279.6	259.1	20.5	15.3
2000		149	295.4	274.9	20.5	15.3

5.1.5 Benefit from the Introduction of the Stage I ATC System

This section deals with evaluation of the improvement of traffic conditions by the introduction of the Stage I ATC System as well as to check the result of computer simulation which the StudyTeam adopted for appraisal of the ATC System expansion plan. To evaluate the ATC System, traffic surveys 'before' and 'after' the installation were conducted on seven (7) routes in the city.

A. Evaluation of Stage I ATC System

1. Changing Traffic Conditions

a, Traffic Volume

For the intersections covered under the Stage I ATC System, the morning and evening peak traffic volumes increased by 4% each whereas the 12-hour traffic volumes increased by 2.8%.

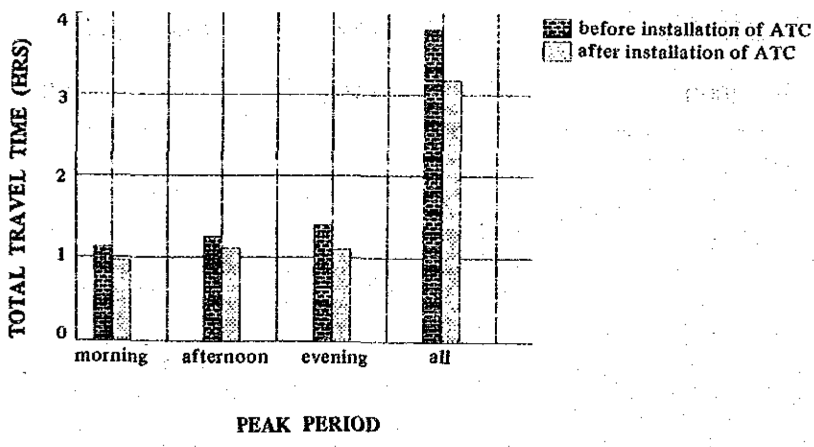
b. Traffic Composition

On the whole, the traffic composition does not experience significant changes.

c. Travel Time

It is observed that the travel time on most of the routes is reduced.

On the whole, the morning peak travel time is reduced by 15%, afternoon peak by 12% and evening peak by as much as 22%. Thus, on the average, the travel time along all the routes considered is reduced by about 16%. Figure 5.1.4 depicts the travel time difference obtained from surveys conducted 'before' and 'after' installation of the Stage I ATC System.



Stage 5.1.4 : Difference of Total Travel Time 'Before' and 'After' Installation of Stage I ATC System

However, this comparison of 'before' and 'after' installation travel time is made with a different base, that is different traffic volume. It must be noted that the 'after installation' traffic volume is higher than that 'before installation'. Thus, if same level of traffic volume is used for 'after installation', then the travel time will be shorter than it was surveyed.

d. Delay Time

For the intersection covered under the Stage I ATC System, the morning and evening peak delay times are reduced by 34% and 25% respectively whereas the daily delay time is reduced by 28%. The intersections of Dato Keramat Road/Perak Road recorded the highest reduction in delay time. This is followed by Magazine Circus. On the other hand, Magazine Road/Ria Road registered the highest increase in delay time.

2. **Actual Benefit**

This section discusses the appraisal of the Stage I ATC System in terms of economic benefit.

Table 5.1.7 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.

a. Estimated difference in delay time

As the result indicated, the Stage I ATC System could be 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.

The difference of the mean annual delay time per intersection is sixty-five thousand (65,000) hours.

b. Benefit estimate for the Stage I ATC System

The benefit derived by computerization of signalized intersections can be measured by the difference in transport cost due to delay time.

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

Table 5.1.7 : Annual Delay Time and Annual Transport Cost 'Before' and 'After Installation of Stage I ATC System

		Annual Delay Time 250 Days x 1000 hr	Time Value $3.80 per PCU hr M$ x 1000	Fuel Cost M$0.57 per PCR hr M$ x 1000	Annual Transport Cost M$ x 1000
Total	B	3498.2	13293.2	1994.0	15287.1
For All	A	2525.5	9596.9	1439.5	11036.4
Intersections	D	–972.7	–3696.3	–554.4	–4250.7
					–27.8%
Average	B	233.2	886.2	132.9	1019.1
Per	A	168.4	639.8	96.0	735.8
Intersection	D	–64.8	–246.4	–37.0	–283.4
					–27.8%

Note : B – 'Before installation'
A – 'After installation'
D – 'Difference'

B. Comparison of Results Between The Field Survey Analysis and Computer Simulation Analysis.

Table 5.1.8 shows the comparison of annual delay time its cost (or benefit) between field survey and computer simulation.

Table 5.1.8 : Comparison of Results Between The Field Survey Analysis and Computer Simulation

	Annual Delay Time (thousand hour)		Annual Transport Cost (M$ million)		Ratio of Annual Delay Time (B/A)
	Survey (A)	Simulation (B)	Survey (A)	Simulation (B)	
Before ATCS	3,490	3,184	15.3	13.9	0.91
After ATCS	2,520	2,384	11.0	10.4	0.94
Difference	970	800	4.3	3.5	0.82

From the comparison of both factors, the values from the simulation are smaller than that of the field survey. This indicates that the simulation value of the benefit due to reduction of delay time by the ATC System is smaller than that of the field survey.

This difference can be expected because effects of geometric improvements at intersections and traffic engineering measures such as road markings, signs, etc. are not considered in the estimate of delay time by the simulation analysis. If these effects are considered, the simulation result would be close to the survey result.

Thus, it is understood that the simulation results in this study is always underestimated by about 18%.

C. Conclusion

1. Benefit and Cost Comparison

The implementation cost for Stage I of the ATC System is M$3.1 million. The estimated benefit that is the reduction of the transport cost due to delay time from the ATC System is M$4.3 million. Therefore the ratio of benefit/cost is about 1.4. It can be expected that the investment cost can be recovered within nine (9) months after the operation of the ATC System. Furthermore, if the non-quantifiable benefits are considered, the recovering period is shorter.

2. Effect of CCTV System

The CCTV System is very useful to monitor the traffic conditions from the Control Centre on main roads and major intersections in the Central Area. This is especially true for the camera installed at the top of KOMTAR Tower as its view covers almost half the entire city.

3. Public Acceptance

The ATC System is capable of tackling bottlenecks, reduce traffic accidents and overcome the occurrence of traffic signal malfunctions typical under the conventional system. This results in smoother and safer traffic flow that will be widely accepted by the public.

4. Acceptance of the result of Computer Simulation Analysis

The computer simulation result which is always underestimated by about 18% compared to the field survey result is acceptable.

5.2 Non-quantifiable Effects of the ATC System

5.2.1 Other Effects of Traffic Signal System

A. Monitor Malfunctioning of Equipment

Equipment monitoring is a function of the ATC System which is concerned with the detection and reporting of control system malfunctions. When malfunctions of local equipment such as local controller, detector, computer system and communication system happen, the system indicates these malfunctions on typewriter and maintenance display map.

It takes a few days for operators to find or recognize the damage of local controllers in case of the previous traffic signal. In addition, it is difficult for road users and traffic engineers to find the damage of traffic detector used for actuated signal control. When the previous actuated signals at several intersections are not functioning they work as a fixed time signal for a long time. Usually this damage is found and repaired only during the periodical maintenance, but it seems that they may not be fixed for half a year and more. Thus, one of the ATC System functions is to operate the system in normal conditions, even if some equipment fails, the time delay to fix them is to be as short as possible.

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.

B. Emergency Vehicle Users

Pre-emption of the right-of-way through signalized intersections for emergency vehicles (usually fire-fighting vehicles) has been achieved by means of directed commands by operators in the Control Centre to change signals green in the direction of the approaching emergency vehicles. Thus these vehicles can arrive quickly at their destination.

C. Control of Vehicle Speed

The computerized signals can be used simply for speed control. The signal time parameters are designed based on a progressive speed on main road so that even if a driver travels over the speed limit he has to wait for green at the downstream intersections. As drivers gain the experiences and awareness of the fact, it is expected that they drive at or near the progressive speed, then such as attitude will promote safe, orderly and efficient movement of traffic.

D. Control of Traffic Volume at certain Locations

By means of computerized signal control at the approaches of critical intersection, the traffic condition at the critical intersection can be controlled and adjusted to avoid more congestion. Furthermore, in case of an accident or major incident, the traffic demand that passes the location can be controlled by upstream signal or signals which can prevent an accumulation of more congestion by limiting the demand passing through the location.

E. Reduction of Air Pollution

Many studies have reported that the hydrocarbon and carbon monoxide level varies depending on the average operational speed of vehicle. Stopping and starting (in particular, on a major signalized arterial street) also have a very drastic effect on hydrocarbon and carbon monoxide emissions from vehicles. The same can be said for the emissions of nitrogen oxide.

The result of the 'before' and 'after' installation of the Stage I ATC System and reports in other countries revealed that computerised signal control system have resulted in an increase in travel speed and reduction of number of vehicular stops at intersections.

Consequently, it is obvious that air pollution from vehicles will be reduced with the introduction of computerized area traffic control system.

F. Reduction of Noise Pollution

Like the reduction of air pollution, the noise level from vehicles will be reduced with computerised area traffic control system. This is because of the increase in travel speed and reduction of number of vehicular stops at intersections.

G. Reduction of Traffic Accidents

Studies have reported the reduction of traffic accidents with computerised signal control system.

The main reasons are :

(1) improvement of drivers' attitude in promoting a safe, orderly and efficient movement of traffic.

(2) the number of vehicular stops at intersections is reduced.

(3) the intersections improvement is made related to implementation of ATC System such as additional lanes, lane marking, traffic signs, etc.

5.2.2 Effect of CCTV System

CCTV in the ATC System is one of the surveillance equipment which has no function of traffic flow control by itself. Thus it is difficult to evaluate the effectiveness of the CCTV System in quantitative value. However, it is obvious from many experiences in other cities that 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 accident.

When the operator wishes to initiate a special service and take action regarding an incident or problem, he needs some visual display of the condition in the system to justify his action.

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

The camera installed at the top of KOMTAR Tower is very efficient as its view covers almost half of the entire city. The traffic conditions on main roads and major intersections in the Central Area can be monitored by the camera alone.

5.2.3 Effect of Driver Information System

Information to drivers 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, or

(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.

Changeable message signs can be useful for route guidance, incident and congestion warnings, land-use designation, weather conditions, and general traffic information.

Driver Information System can produce 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.

5.2.4 Effects of Statistical Data Collection System

The ATC System has traffic detectors which will be installed at approximately two hundred (200) locations along main road to obtain traffic information such as traffic volume and occupancy (if necessary, speed information) and transmit them to the control centre. These information will be used as basic data for purposes of traffic signal control, real-time traffic condition display, driver information system and detection of incidents.

Furthermore, these data will 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 plan and so on.

The benefit in monetary value of the statistics reports is difficult to quantify. However, the estimated cost of making such a report including a traffic survey and analyses is about M$100,000 per year assuming a collection of the 24 hour traffic volume and speed data at ten (10) locations for one day of each month.

5.3 Cost Estimation for the ATC System

5.3.1 Estimation Process

The cost for the ATC System is calculated in 1986 prices, and consists of four (4) basic elements, that is

(1) System cost
(2) Operation cost
(3) Intersection improvement cost
(4) Renewal cost

The cost of each element can be further divided into foreign currency and local currency portions.

For the ATC System, foreign currency is incurred on:

- System cost except installation cost
- Renewal cost

Local currency is incurred as :

- Installation cost
- Operation cost
- Intersection improvement cost

Each of the abovementioned cost elements will be described in the following sections.

A. System Cost

The system cost is estimated in accordance to the system configuration which is depicted in the Supplementary Volume : Drawings. The system cost for each sub-system* is based on the following items:

- Central equipment
- Software
- Terminal equipment
- Installation
- Insurance and others

The breakdown of system cost estimates for each stage is shown in Table 5.3.1

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* Basically, the ATC System comprises four (4) sub-systems, that is

- Traffic Signal Control System
- Statistical Data Collection System
- CCTV System and
- Driver Information System

B. **Operation Cost**

The operation cost is estimated in each stage including Stage I System and includes the following items :

- Staff salary
- Electricity
- Line rental
- Maintenance
- Parts and others

The breakdown of operation cost estimates for each stage is shown in Table 5.3.2.

C. **Intersection Improvement Cost**

The estimation of intersection improvement cost is based on the following items :

- Pavement for carriageway and pedestrian
- Kerbs installation
- Drainage works
- Demolition cost for trees on existing structures
- Road markings
- Others

Table 5.3.3 shows the breakdown of intersection improvement cost estimates for each stage.

D. **Renewal Cost**

The renewal cost is estimated as the same price as the system cost in Stages I and II because generally the life of ATC System does not last for more than ten years. Thus, the system in Stages I (1986) and II (1990) will have to be renewed in 1996 and 2000 respectively.

The breakdown of cost estimate for Bayan Lepas sub-station is presented in Table 5.3.4.

5.3.2 Estimated Cost

Table 5.3.5 summarises the estimated installation cost for the ATC System for the Study Area excluding the Expressway Surveillance and Control System.

For the completion of Stage I, a sum of M$3.1 million had been allocated by the MPPP.

In the initial stage of the ATC System Expansion Plan (Stage II), the bulk of the cost is for additional Terminal Equipment of Traffic Signal Control System covering forty-four (44) intersections. The estimated installation cost for Stage II is about M$7.8 million.

In the next stage (Stage III), the addition of a Host Computer, Terminal Equipment for fifty-nine (59) intersections, Driver Information System and Others is estimated to cost about M$20.0 million.

In Stage IV, the Bayan Lepas Sub-station for controlling thirty (30) intersections is estimated to cost about M$9.2 million.

Table 5.3.6 depicts the total costs, that is, construction and operation costs, according to phases for the ATC System. The total cost for the ATC System is estimated to be M$53.5 million.

Table 5.3.1(1) : System Cost – Traffic Signal Control System (TSCS) and Statistical Data Collection System (SDCS)

	Particulars	Unit	Stage I Foreign Qty	Stage I Foreign Cost	Stage I Local Qty	Stage I Local Cost	Stage I Total Cost	Stage II Foreign Qty	Stage II Foreign Cost	Stage II Local Qty	Stage II Local Cost	Stage II Total Cost	Stage III Foreign Qty	Stage III Foreign Cost	Stage III Local Qty	Stage III Local Cost	Stage III Total Cost	Stage IV Foreign Qty	Stage IV Foreign Cost	Stage IV Local Qty	Stage IV Local Cost	Stage IV Total Cost
1.	CENTRAL EQUIPMENT:																					
1.1	Host Computer System:																					
	ATC Mini-computer	Nos.	–	–	–	–	–	–	0	–	0	0	1	560	–	0	560	–	0	–	0	0
	Peripheral Device	LS	–	–	–	–	–	–	0	–	0	0	LS	820	–	0	820	–	0	–	0	0
	Power Supplier & Others	LS	–	–	–	–	–	–	0	–	0	0	–	0	–	0	0	LS	466	–	0	466
1.2	Signal FEP:																					
	ATC Micro-Computer	Nos.	–	–	–	–	–	–	0	–	0	0	1	395	–	0	395	1	395	–	0	395
	Modem Unit	Nos.	–	–	–	–	–	45	110	–	0	110	–	0	–	0	0	–	0	–	0	0
1.3	MDF	LS	–	–	–	–	–	–	0	–	0	0	LS	50	–	0	50	–	0	–	0	0
1.4	Emergency Power Supplier:																					
	Engine Generator	LS	–	–	–	–	–	LS	179	–	0	179	LS	238	–	0	238	–	0	–	0	0
	CVCF	LS	–	–	–	–	–	LS	262	–	0	262	LS	596	–	0	596	–	0	–	0	0
1.5	Parts and Others	LS	–	–	–	–	–	LS	58	–	0	58	LS	174	–	0	174	–	0	–	0	0
	Sub-Total			–		–	–		609		0	609		2833		0	2833		861		0	861
2.	SOFTWARE:																					
2.1	Host Computer Program	LS	–	–	–	–	–	–	0	–	0	0	LS	2763	–	0	2763	–	0	–	0	0
2.2	Signal FEP Program	LS	–	–	–	–	–	–	0	–	0	0	LS	395	–	0	395	LS	395	–	0	395
2.3	Timing Parameter Design	Nos.	–	–	–	–	–	45	355	–	0	355	58	457	–	0	457	30	236	–	0	236
2.4	Testing and Others	LS	–	–	–	–	–	LS	93	–	0	93	LS	203	–	0	203	–	0	–	0	0
	Sub-Total			–		–	–		448		0	448		3818		0	3818		631		0	631
3.	TERMINAL EQUIPMENT:																					
3.1	Signal Controller	Nos.	–	–	–	–	–	45	1774	–	0	1774	58	2302	–	0	2302	25	935	–	0	935
3.2	Loop Detector	Nos.	–	–	–	–	–	90	569	–	0	569	116	733	–	0	733	60	379	–	0	379
3.3	Parts and Others	LS	–	–	–	–	–	LS	96	–	0	96	LS	164	–	0	164	–	0	–	0	0
	Sub-Total			–		–	–		2439		0	2439		3199		0	3199		1314		0	1314
4.	INSTALLATION:																					
4.1	Central Equipment	LS	–	–	–	–	–	–	0	LS	8	8	–	0	LS	120	120	–	0	LS	27	27
4.2	Signal Controller	Nos.	–	–	–	–	–	–	0	45	996	996	–	0	58	2127	2127	–	0	25	916	916
4.3	Detector	Nos.	–	–	–	–	–	–	0	90	180	180	–	0	116	232	232	–	0	60	120	120
	Sub-Total			–		–	–		0		1184	1184		0		2479	2479		0		1063	1063
	Total			2287		713	3000		3496		1184	4680		9850		2479	12329		2806		1063	3869

Table 5.3.1(2) : System Cost – Closed Circuit Television System (CCTV)

Particulars	Unit	Stage I Foreign Qty	Stage I Foreign Cost	Stage I Local Qty	Stage I Local Cost	Stage I Total Cost	Stage II Foreign Qty	Stage II Foreign Cost	Stage II Local Qty	Stage II Local Cost	Stage II Total Cost	Stage III Foreign Qty	Stage III Foreign Cost	Stage III Local Qty	Stage III Local Cost	Stage III Total Cost	Stage IV Foreign Qty	Stage IV Foreign Cost	Stage IV Local Qty	Stage IV Local Cost	Stage IV Total Cost
1. CENTRAL EQUIPMENT:																					
1.1 Central Controller	Nos.	–	–	–	–	–	2	350	–	0	350	1	175	–	0	175	1	175	–	0	175
1.2 CCTV Monitor TV	Nos.	–	–	–	–	–	8	33	–	0	33	6	25	–	0	25	2	9	–	0	0
1.3 Parts and Others	LS	–	–	–	–	–	LS	41	–	0	41	LS	40	–	0	40	–	0	–	0	0
Sub-Total			–		–	–		424		0	424		240		0	240		184		0	184
2. Camera and Controller	Nos.	–	–	–	–	–	8	400	–	0	400	6	300	–	0	300	2	100	–	0	100
3. INSTALLATION:																					
3.1 CCTV Camera	Nos.	–	–	–	–	–	–	0	8	73	73	–	0	6	55	55	–	0	2	18	18
3.2 CCTV Cable	km.	–	–	–	–	–	–	0	14	206	206	–	0	24	352	352	–	0	5	73	73
Sub-Total			–		–	–		0		279	279		0		407	407		0		91	91
Total			–		–	–		824		279	1103		540		407	947		284		91	375

Table 5.3.1(3) : System Cost – Driver Information System (DIS)

Particulars	Unit	Stage I Foreign Qty	Stage I Foreign Cost	Stage I Local Qty	Stage I Local Cost	Stage I Total Cost	Stage II Foreign Qty	Stage II Foreign Cost	Stage II Local Qty	Stage II Local Cost	Stage II Total Cost	Stage III Foreign Qty	Stage III Foreign Cost	Stage III Local Qty	Stage III Local Cost	Stage III Total Cost	Stage IV Foreign Qty	Stage IV Foreign Cost	Stage IV Local Qty	Stage IV Local Cost	Stage IV Total Cost
1. CENTRAL EQUIPMENT:																					
1.1 DIS FEP	Nos.	–	–	–	–	–	–	0	–	0	0	1	395	–	0	395	–	0	–	0	0
1.2 Peripherals (wall map, etc)	LS	–	–	–	–	–	–	0	–	0	0	LS	984	–	0	984	–	0	–	0	0
1.3 Parts and Others	LS							0		0	0	LS	54	–	0	54	–	0	–	0	0
Sub-Total			–		–	–		0		0	0		1433		0	1433		00		0	0
2. SOFTWARE:																					
2.1 DIS Program	LS	–	–	–	–	–	–	0	–	0	0	LS	592	–	0	592	–	0	–	0	0
2.2 Message Program	LS	–	–	–	–	–	–	0	–	0	0	LS	17	–	0	17	LS	26	–	0	26
2.3 Testing and Others	LS	–	–	–	–	–	–	0	–	0	0	LS	34	–	0	34	LS	25	–	0	25
Sub-Total			–		–	–		0		0	0		643		0	643		51		0	51
3. TERMINAL EQUIPMENT:																					
3.1 Controller	Nos.	–	–	–	–	–	–	0	–	0	0	2	198	–	0	198	3	298	–	0	298
3.2 Signboard	Nos.	–	–	–	–	–	–	0	–	0	0	2	1000	–	0	1000	3	1500	–	0	1500
3.3 Parts and Others	LS	–	–	–	–	–	–	0	–	0	0	LS	45	–	0	45	LS	98	–	0	98
Sub-Total			–		–	–		0		0	0		1243		0	1243		1896		0	1396
4. INSTALLATION:																					
4.1 Central Equipment	LS	–	–	–	–	–	–	0	–	0	0	–	0	LS	25	25	–	0	LS	0	0
4.2 Terminal Equipment	Nos.	–	–	–	–	–	–	0	–	0	0	–	0	2	83	83	–	0	3	125	125
Sub-Total			–		–	–		0		0	0		0		108	108		0		125	125
Total			–		–	–		0		0	0		3319		108	3427		1947		125	2072

Table 5.3.1(4) : System Cost – Insurance & Others

Particulars	Unit	Stage I Foreign Qty	Stage I Foreign Cost	Stage I Local Qty	Stage I Local Cost	Stage I Total Cost	Stage II Foreign Qty	Stage II Foreign Cost	Stage II Local Qty	Stage II Local Cost	Stage II Total Cost	Stage III Foreign Qty	Stage III Foreign Cost	Stage III Local Qty	Stage III Local Cost	Stage III Total Cost	Stage IV Foreign Qty	Stage IV Foreign Cost	Stage IV Local Qty	Stage IV Local Cost	Stage IV Total Cost
1. Insurance & Transport	LS	–	–	–	–	–	LS	92	–	0	92	–	379	–	0	379	LS	34	–	0	34
2. Training	LS	–	–	–	–	–	LS	66	–	0	66	–	133	–	0	133	LS	25	–	0	25
3. Ist. Yr. Maintenance Others	LS	–	–	–	–	–	LS	188	–	0	188	–	629	–	0	629	LS	101	–	0	101
Total			–		–	–		346		0	346		1141		0	1141		160		0	160

Table 5.3.2 : Operation Cost

Particulars	Unit	Stage I Foreign Qty	Stage I Foreign Cost	Stage I Local Qty	Stage I Local Cost	Stage I Total Cost	Stage II Foreign Qty	Stage II Foreign Cost	Stage II Local Qty	Stage II Local Cost	Stage II Total Cost	Stage III Foreign Qty	Stage III Foreign Cost	Stage III Local Qty	Stage III Local Cost	Stage III Total Cost	Stage IV Foreign Qty	Stage IV Foreign Cost	Stage IV Local Qty	Stage IV Local Cost	Stage IV Total Cost
1. Staff Salary	Person		0	1	14	14		0	1	14	14		0	2	28	28		0	2	28	28
2. Electricity	Nos.	–	0	16	24	24	–	0	45	68	68	–	0	58	87	87	–	0	40	60	60
3. Line Rental	Nos.	–	0	16	8	8	–	0	45	23	23		0	58	29	29	–	0	40	20	20
4. Maintenance	Nos.	–	0	16	32	32	–	0	45	90	90	–	0	58	116	116	–	0	40	80	80
5. Parts & Others	LS	–	0	LS	15	15	–	0	LS	23	23	–	0	LS	132	132	–	0	LS	69	69
Total			0		93	93		0		218	218		0		392	392		0		257	257

Table 5.3.3 : Intersection Improvement

Particulars	Unit	Stage I Foreign Qty	Stage I Foreign Cost	Stage I Local Qty	Stage I Local Cost	Stage I Total Cost	Stage II Foreign Qty	Stage II Foreign Cost	Stage II Local Qty	Stage II Local Cost	Stage II Total Cost	Stage III Foreign Qty	Stage III Foreign Cost	Stage III Local Qty	Stage III Local Cost	Stage III Total Cost	Stage IV Foreign Qty	Stage IV Foreign Cost	Stage IV Local Qty	Stage IV Local Cost	Stage IV Total Cost
1. Pavement (Carriageway):																					
1.1 New Construction	sq.m	–	–	–	–	–	–	0	4521	151	151	–	0	5000	167	167	–	0	2605	87	87
1.2 Surfacing	sq.m	–	–	–	–	–	–	0	5413	96	96	–	0	5971	107	107	–	0	3069	55	55
Sub-total			–		–	–		0		247	247		0		274	274		0	5674	142	142
2. Pavement (Pedestrian):																					
2.1 Sidewalk	sq.m	–	–	–	–	–	–	0	1674	30	30	–	0	2176	39	39	–	0	1172	21	21
2.2 Median	sq.m	–	–	–	–	–	–	0	391	7	7	–	0	558	10	10	–	0	223	4	4
2.3 Island	sq.m	–	–	–	–	–	–	0	1842	33	33	–	0	2400	43	43	–	0	1283	23	23
Sub-Total			–		–	–		0		70	70		0		92	92		0		48	48
3. Kerbs:																					
3.1 Sidewalk	sq.m	–	–	–	–	–	–	0	1575	31	31	–	0	2134	42	42	–	0	1067	21	21
3.2 Median	sq.m	–	–	–	–	–	–	0	965	19	19	–	0	1169	23	23	–	0	661	13	13
3.3 Island	sq.m	–	–	–	–	–	–	0	1575	31	31	–	0	2134	42	42	–	0	1067	21	21
Sub-Total			–		–	–		0		81	81		0		107	107		0		55	55
4. Drainage:																					
4.1 Culvert	m	–	–	–	–	–	–	0	48	11	11	–	0	65	15	15	–	0	30	7	7
4.2 Scuppers	m	–	–	–	–	–	–	0	51	1	1	–	0	51	1	1	–	0	51	1	1
4.3 Resiting of drains (12 ins.)	m	–	–	–	–	–	–	0	217	20	20	–	0	294	27	27	–	0	152	14	14
Sub-Total			–		–	–		0		32	32		0		43	43		0		22	22
5. Demolition Cost:																					
5.1 Trees	Nos.	–	–	–	–	–	–	0	5	5	5	–	0	6	6	6	–	0	3	3	3
5.2 Roundabout	sq.m	–	–	–	–	–	–	0	781	14	14	–	0	–	0	0	–	0	–	0	0
5.3 Existing Structures	sq.m	–	–	–	–	–	–	0	781	14	14	–	0	1004	18	18	–	0	558	10	10
Sub-Total			–		–	–		0		33	33		0	1010	24	24		0		13	13
6. *Road Markings*	*m*	–	–	–	–	–	–	0	20087	46	46	–	0	26638	61	61	–	0	13537	31	31
7. Plus 20% Contigencies		–	–	–	–	–	–	0	–	102	102	–	0		120	120	–	0		62	62
Total			–		–	–		0		611	611		0		721	721		8		373	373

Table 5.3.4 : Bayan Lepas Sub-station Cost

		Stage I					Stage II					Stage III					Stage IV				
		Foreign		Local		Total	Foreign		Local		Total	Foreign		Local		Total	Foreign		Local		Total
Particulars	Unit	Qty	Cost	Qty	Cost	Cost	Qty	Cost	Qty	Cost	Cost	Qty	Cost	Qty	Cost	Cost	Qty	Cost	Qty	Cost	Cost
I. TSCS & SDCS:																					
I.1 CENTRAL EQUIPMENT:																					
. ATC Micro-computer	Nos.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	395	–	0	395
. Power Supplier & Others	LS	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	LS	466	–	0	466
Sub-Total			–		–	–		–		–	–		–		–	–		861		0	861
I.2 SOFTWARE:																					
. Signal FEP	LS	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	LS	395	–	0	395
. Timing Parameter Design	Nos.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	30	236	–	0	236
Sub-Total			–		–	–		–		–	–		–		–	–		631		0	631
I.3 TERMINAL EQUIPMENT:																					
. Signal Controller	Nos.	–	–	–	–	–	5	234	–	0	234	–	–	–	–	–	25	935	–	0	935
. Loop Detector	Nos.	–	–	–	–	–	10	63	–	0	63	–	–	–	–	–	60	379	–	0	379
Sub-Total			–		–	–		297		0	297		–		–	–		1314		0	1314
I.4 INSTALLATION:																					
. Central Equipment	LS	–	–	–	–	–	–	0	–	0	0	–	–	–	–	–	–	0	LS	27	27
. Signal Controller	Nos.	–	–	–	–	–	–	0	LS	183	183	–	–	–	–	–	–	0	25	916	916
. Detector	Nos.	–	–	–	–	–	–	0	–	0	0	–	–	–	–	–	–	0	60	120	120
Sub-Total			–		–	–		0		183	183		–		–	–		0		1063	1063
Total			–		–	–		297		183	480		–		–	–		2806		1063	3869
II. CCTV SYSTEM:																					
II.1 CENTRAL EQUIPMENT:																					
. Central Controller	Nos.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	175	–	0	175
. CCTV Monitor TV	Nos.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	9	–	0	9
Sub-Total			–		–	–		–		–	–		–		–	–		184	–	0	184
II.2 Camera & Coktroller	Nos.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	100	–	0	100
II.3 INSTALLATION:																					
. CCTV Camera	Nos.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	2	18	18
. CCTV Cable	km.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	5	73	73
Sub-Total			–		–	–		–		–	–		–		–	–		0		91	91
Total			–		–	–		–		–	–		–		–	–		284			375
III. DIS:																					
III.1 Message Program	LS	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	LS	18	–	0	18
III.2 Controller	Nos.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	198	–	0	198
III.3 Signboard	Nos.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	1000	–	0	1000
III.4 Terminal Equip. Install.	Nos.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	2	83	83
Total			–		–	–		–		–	–		–		–	–		1216		83	1299
Grand Total for Bayan Lepas Sub-station		–	–		–	–	–	297	–	183	480		–		–	–		4306		1146*	5543

Table 5.3.5 : Installation Cost of ATC System Expansion Plan

(M$1,000, 1986 Price)

		Stage I	Stage II	Stage III	Stage IV	Total
1.	System Cost					
	Traffic Signal Control System & Statistical Data 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	–	7,339	19,266	8,785	35,290
3.	Intersection Improvement Cost	–	611	721	373	1,705
	Grand Total	–	7,850	19,987	9,158	36,995

Notes : Tax is not included in the cost estimation.
* Cost for Bayan Lepas Area.

Table 5.3.6 : Total Costs According to Phase

(M$1,000, 1986 Price)

	Year	Stage I		Stage II		Stage III		Stage IV		All Stages		
		A	B	A	B	A	B	A	B	A	B	Total
Phase 1	1988		93								93	93
	1989		93								93	93
	1990		93	7850						7850	93	7943
		0	279	7850	0	0	0	0	0	7850	279	8129
Phase 2	1991		93		218						311	311
	1992		93		218						311	311
	1993		93		218						311	311
	1994		93		218	19987				19987	311	20298
	1995		93		218		392				703	703
		0	465	0	1090	19987	392	0	0	19987	1947	21934
Phase 3	1996	3100	93		218		392			3100	703	3803
	1997		93		218		392	9158		9158	703	9861
	1998		93		218		392		257		960	960
	1999		93		218		392		257		960	960
	2000		93	6893	218		392		257	6893	960	7853
		3100	465	6893	1090	0	1960	9158	771	19151	4286	23437
Total		3100	1209	14743	2180	19987	2352	9158	771	46988	6512	53500

Notes : A – Construction Cost
B – Operation Cost

6.0 ECONOMIC EVALUATION

6.1 Introduction

The implementation of the ATC System Plan involves substantial capital expenditure. Such expenditure has to be economically justified.

An economic evaluation will determine whether or not the economic benefit of the proposed ATC System Plan justifies its implementation.

The economic evaluation procedure involves a comparison of cost and benefit.

The comparison is expressed as :

(1) Internal rate of return (IRR)
(2) Benefit cost ratio (B/C)
(3) Net present value (NPV)

6.2 Economic Evaluation

A. Economic Cost :

Economic costs are composed of the following five items:

(1) Initial cost for ATC System
(2) Intersection improvement cost
(3) Renewal cost for ATC System
(4) Operation cost
(5) Residual cost

These costs are shown in Table 6.2.1.

Table 6.2.1 : Economic Costs for ATC System

Unit : M$1,000 at 1986 Price

		Stage I	Stage II	Stage III	Stage IV	Total
Initial Cost for ATC System	Foreign	–	5627	16634	7191	29452
	Local	–	12	632	1594	5838
	Total	–	5639	17266	8785	35290
Intersection Improvement Cost	Total	–	611	721	373	1705
Sub Total			7850	19987	9158	36995
Renewal Cost for ATC System*	Total	(3100)	6893	18372	–	25265
Annual Operation Cost	Labour	(40)	104	144	108	356
	Others	(53)	114	248	149	511
	Total	(93)	218	392	157	867
Residual Cost		(Changeable by implementation program)				

Note : * Renwal period of the system is 10 years
The total cost does not include the cost of Stage I

B. Benefit

The benefit is calculated on the saving of travel time and fuel consumption which will be induced by the proposed expansion plan of ATC System.

The benefit will be M$15.3 million in year 2000 after completion of the proposed plan estimated by the traffic flow simulation model.

C. Economic Evaluation

Table 6.2.2 shows the yearly stream of costs and benefits.

As the economic evaluation shows the investment in this plan could yield a net present value of M$25 million and a benefit cost ratio of 2.3 and an internal rate of return of 22.7%. Table 6.2.3 depicts the economic indicators of the proposed ATC System Plan.

Hence, the proposed ATC System Plan is found to be economically feasible and is recommended as the ATC System Plan 2000 for Penang.

Table 6.2.2 : Yearly Stream of Costs and Benefits

(M$1,000 at 1986 Prices)

Year	Undiscounted Costs by Stage									Undiscounted Benefits	Discounted at 12%	
	Stage I		Stage II		Stage III		Stave IV		Total			
	A	B	A	B	A	B	A	B			Costs	Benefits
1987									0	0	0	0
1988									0	0	0	0
1989									0	0	0	0
1990			7850						7850	0	4989	0
1991				218					218	4700	124	2667
1992				218					218	4900	110	2482
1993				218					218	4900	99	2217
1994				218	19987				20205	4800	8160	1939
1995				218		392			610	12900	220	4652
1996				218		392			610	13500	196	4347
1997				218		392	9158		9768	13900	2808	3996
1998				218		392		257	867	15300	223	3927
1999				218		392		257	867	15300	199	3506
2000			6893	218		392		257	7760	15300	1588	3131
2001				218		392		257	867	15300	158	2795
2002				218		392		257	867	15300	141	2496
2003				218		392		257	867	15300	126	2228
2004				218	18372	392		257	19239	15300	2502	1990
2005			–3447	218	–16535	392	–1676	257	–20790	15300	–2414	1776
Total									50241	182000	19229	44149

Note : A – Construction
B – Operation

Table 6.2.3 : Economic Indicators of Proposed ATC System Plan

Internal Rate of Return (%)	22.70
Benefit Cost Ratio	2.30
Net Present Value (1000 M$)	24919.00

D. Sensitivity Analysis

As the second step of the economic evaluation, a sensitivity analysis on the benefit and cost estimate is made.

The factors to be tested in this sensitivity analysis are considered as follows:

a. Benefits

a.1 10% Reduction of benefit
a.2 20% Reduction of benefit

b. Cost

b.1 100% Increase of operation cost
b.2 20% Increase of construction cost and Operation cost
b.3 50% Increase of construction cost Operation cost

c. Combination of Factors

c.1 20% Reduction of benefit and
20% Increase of cost
c.2 20% Reduction of benefit and
50% Increase of cost

Table 6.2.4 shows the results of the sensitivity analysis.

(1) Although the benefit is reduced by 20% of the original estimate, the proposed ATC System Plan is still found to be economically feasible.

(2) Although the cost is increased by 50% of the original estimate, the proposed plan is still economically feasible.

(3) Although the benefit is reduced by 20% and the cost is increased by 50% of original estimates, the proposed plan is also considered to be economically feasible.

Table 6.2.4 : Sensitivity Analysis on the Benefit/Cost of the ATC System

Factors	IRR	B/C	NPC
Proposed Plan	22.7%	2.30	24919
a. 1	20.9%	1.93	22127
a. 2	18.2%	1.57	16127
b. 1	20.4%	1.76	20979
b. 2	18.2%	1.64	18573
b. 3	16.2%	1.31	13091
c. 1	16.0%	1.31	10473
c. 2	12.8%	1.05	1991

E. Conclusion

The results of the economic evaluation clearly show that the expansion of the ATC System is economically feasible and is recommended to be implemented in Penang.

7.0 EVALUATION REPORTS OF THE ATC SYSTEM IN OTHER COUNTRIES

A. The National Signal Timing Optimization Project in USA

The report states the Federal Highway Administration's role in energy conservation efforts and introduced the National Signal Timing Optimization Project. The following project activities were undertaken.

(1) Development of the TRANSYT–7F signal timing optimization program and provision of training in its use.

(2) Application of the program in 11 cities nationwide to evaluate the effectiveness of optimized signal timing plans and to collect data on the needed resources.

This report also presents the project results that for the average intersection in the project, 15,470 vehicle-hours of delay were saved, 455,921 vehicle stops were eliminated and 10,524 gallons of fuel were saved each year. The equivalent US dollar total annual benefit per signal averaged $28,695. With an average equivalent dollar total annual benefit per intersection and average cost to conduct a first-time project per intersection the benefit/cost ratio is an impressive 63 to 1.

B. *The TEAM Project in Manila*

The report of Metro Manila TEAM Project Phase I describes that the traffic control system and traffic engineering improvements implemented in Phase I of the TEAM Project has improved the quality of service or traffic conditions and also increased the capacity of the street system. The evaluation study report of the Phase I system states that the average peak hour traffic volume on those routes with computer controlled signals increased dramatically, ranging from 8% to 58%. It also reported that the average casualty and total accident rates was reduced by 14% and 27% respectively. The system is well accepted by Manila drivers and getting favourable attention from the press and the people.

C. Research Report of effectiveness of Traffic Safety Facility – Area Traffic Signal Control System in Japan

The research purpose of this report is to evaluate the effectiveness by investment of traffic safety facilities, in particular, traffic signal facility controlled by central computer established by 1983 in 87 control centres nation wide.

The main evaluation factors are reduction of accident rate, travel time, stop duration, vehicle stops, while increasing travel speed, etc. The evaluation involves the comparison of these factors before and after completion of these facilities.

It was reported that both the numbers of injured accidents and fatal accidents have decreased after signal operation from a central computer control was implemented. This is shown as below:

	Unit	Injured Accidents	Fatal Accidents
6 months before Centralized Control	Nos.	48,383	628
6 months after Centralized Control	Nos.	44,816	560
Difference	Nos.	3,567	68
Average Decrease on 1 km section	Acc/km	1.598	0.031
Average Decrease at at intersection	Acc/set of signal	0.671	0.013

The report also states that travel time, stop duration and vehicle stops have decreased while travel speed has increased after the computerized signal control. It is obvious that the smoothness of traffic movements on urban street is enhanced and improved by the introductionof ATC system.

The results are summarized in the following tabulation.

	Change per 1 km section	Change per a set of signal
Travel time	26.5 secs/km	6.8 secs/set
Stop duration	13.7 secs/km	3.6 secs/set
Vehicle stops	0.6 stops/km	0.14 stops/set
Travel Speed	3.6 km/h	N.A.

Part II

Pedestrian Path Network Plan in Central Area

PART II : PEDESTRIAN PATH NETWORK PLAN IN CENTRAL AREA

1.0 INTRODUCTION

The average trip length covered by a Malaysian pedestrian on urban streets is not very long. It is partly attributed to the local hot and humid climatic conditions, and partly to the physical discomfortness associated with walking along corridor having unequal levels and having to make dangerous road crossing.

Creation and improvement of pedestrian facilities play an important role in encouraging greater pedestrian mobilities. Moreover, people are willing to walk further when a trip make on foot is less tedious and more comfortable.

In addition, creation of a good pedestrian walkway system that links one major part of the city to another is one factor that adds to the quality of urban life in the city. Improvements to pedestrians facilities has the immediate objectives of making movement on foot safer, easier, quicker, healthier and more pleasant. briefly

Urban pedestrian demand will inevitably increase with the implementation of measures to attract a higher share of public transportation usage or the establishment of parking facilities at strategic locations in the city. In view of a variety of activities in the urban areas, an all out effort should be undertaken to provide better facilities for the pedestrians and by implementing a pedestrian path network in the city.

2.0 PEDESTRIAN PATH NETWORK PLAN – ALTERNATIVE III NETWORK

The proposed path network, namely the Alternative III Network, has been breifly introduced in Section A of this Report. The following sections will focus on details on pedestrianisation improvement measures for roadway sections in the network.

2.1 Classification of Pedestrian Path Network

The proposed network is categorized into primary and secondary pedestrian pathway. The former provides essential linkage amongst various core areas of diversified activities and areas of interest in the city. The latter serves as a supporting or supplementary pedestrian route linkage to the primary routes. Figure 2.1.1 illustrates the pathway as classified under the Alternative III Network.

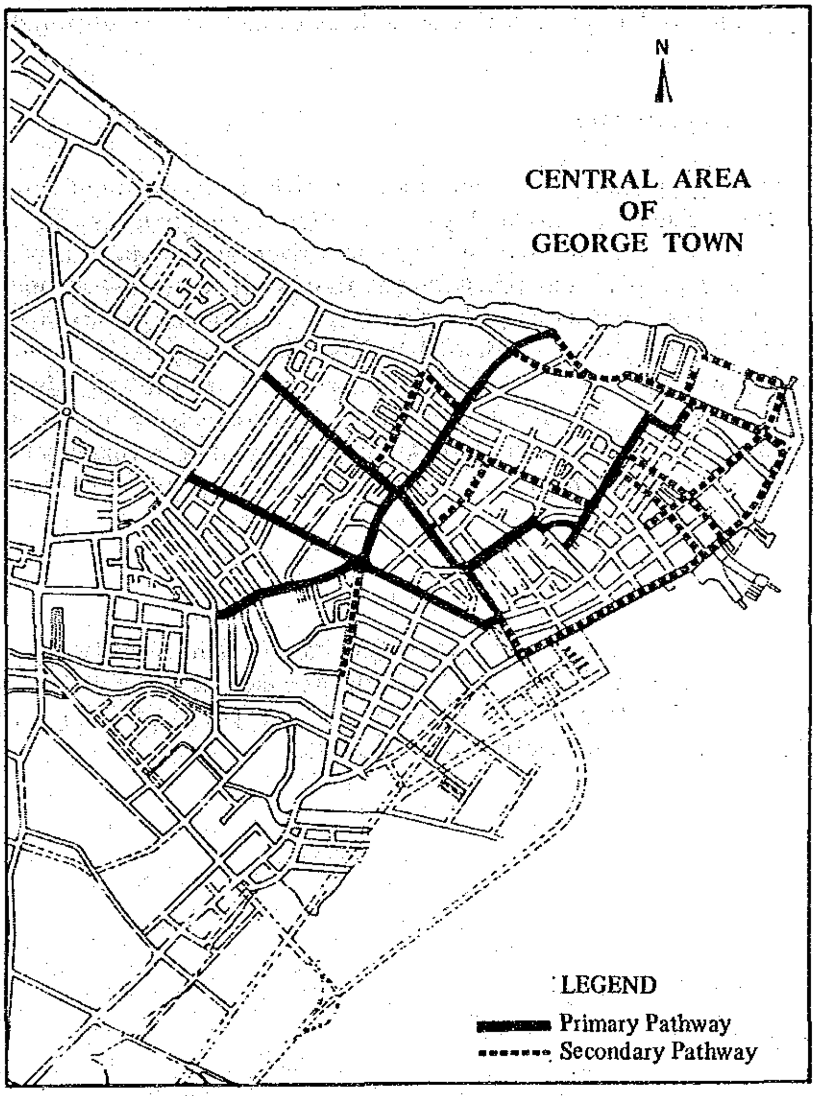


Figure 2.1.1 : Classification of Pedestrian Pathway In The Network

2.2 Types of Sidewalk in the Pedestrian Network

The existing type of sidewalk or the footway in the urban area are of the corridor (commonly known as five-footway in Penang) and pavement type. Structurally, the corridor does not provide a pleasant pedestrian movement. However, in lieu with the pedestrian path network concept, the types of sidewalk are reinstated. Primarily, the walkway system in this network consists of pedestrian mall, community street and pavement.

A. Pedestrian Mall

The mall is a level and shaded sidewalk encompassing a vast area which enables pedestrians to window-shop or stroll freely without being disturbed or endangered by traffic. It is restricted to pedestrian use only by prohibiting the entry of traffic but allows emergency entry for ambulance or fire engine. Amenities such as trees, shrubs, and street furniture are introduced to the public as leisure facilities as well as enhancing the surrounding street vista. (Figure 2.2.1).

B. Community Street

This is an innovative pedestrianised street concept found commonly amongst the residential areas in Japan. The street design takes into consideration of usage by both the community cars driven at low speed and pedestrian alike. Where possible and practical, the footpath is extended to mid-block alleys to provide a continuous pedestrian access. The concept introduces a part of the 'woonerf' concept originated in Holland. Ornamental and attractive settings are part and parcel of the community street concept to enhance its image as a unique and prominent landmark. The objectives are foreseeable with an introduction of unique street lamps and attractive paving blocks on carriageway and sidewalk. Figure 2.2.2 illustrates two examples of community streets in Japan.

C. Pavement

The effective width of the existing pavement in the city is generally between 1 m to 3 m (Figure 2.2.3). Improvement on the existing ones need to be undertaken to provide a pleasant and quality walking conditions rendered with some landscaping works where possible.

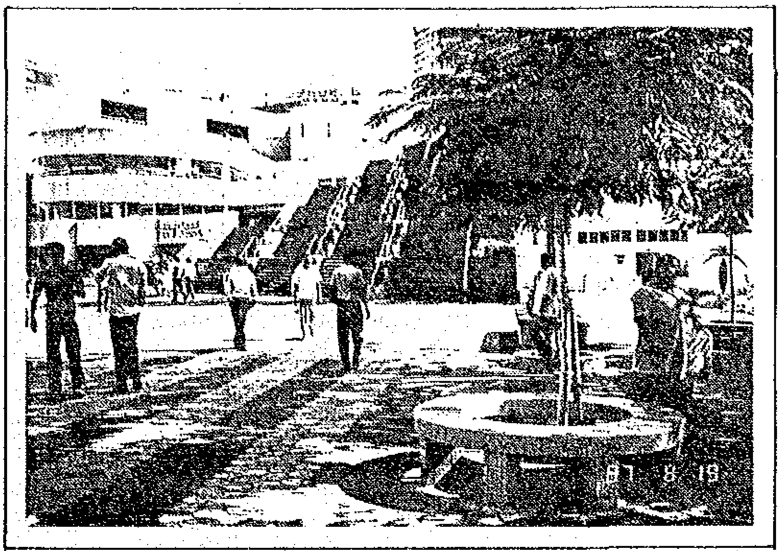


Figure 2.2.1 : Pedestrian Mall At Super KOMTAR

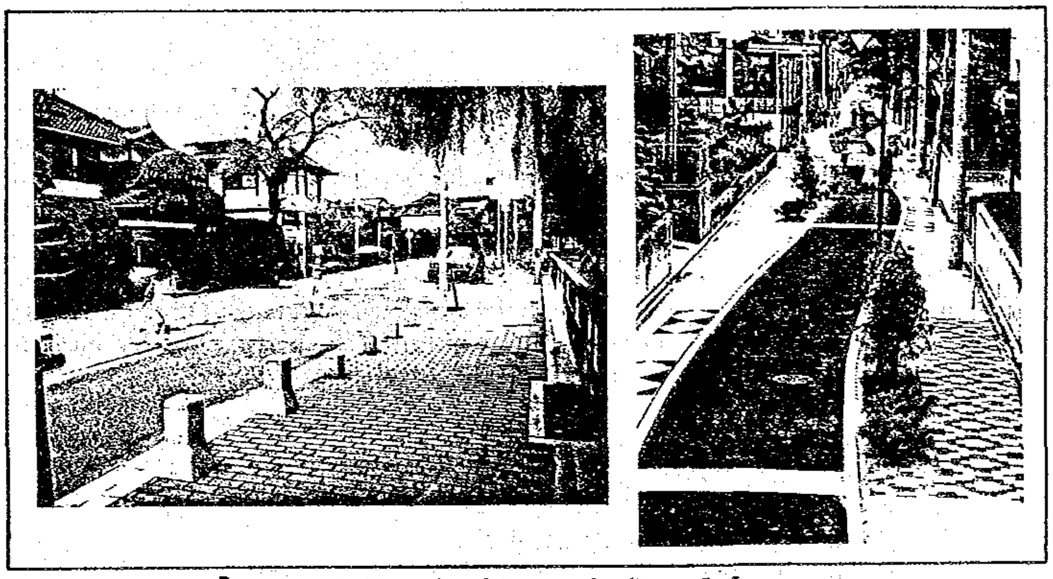


Figure 2.2.2 : Examples of Community Streets In Japan

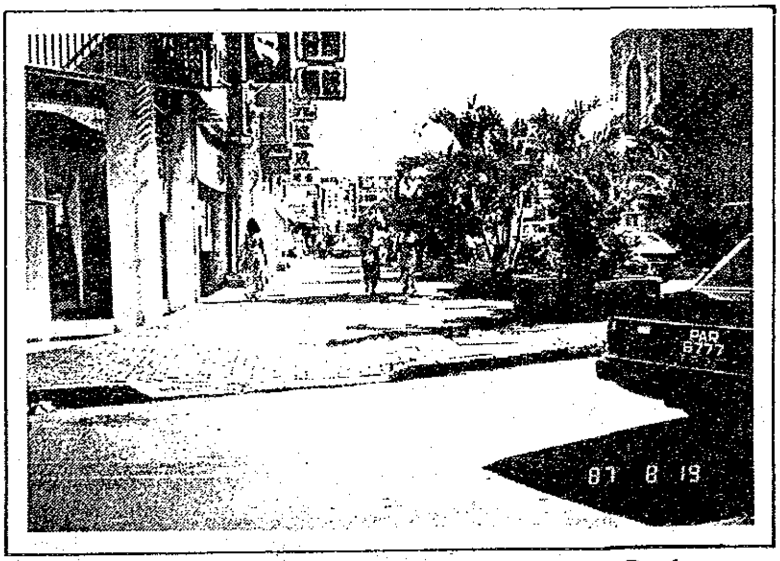


Figure 2.2.3 : Landscaped Pavement Along Penang Road

Types of sidewalk proposed for the network is illustrated in Figure 2.2.4. The network is composed primarily of landscaped pavement. However, a pedestrian mall is proposed along the stretch of Maxwell Road (between KOMTAR 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 condition 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 vicinities. In addition, a pedestrian deck is proposed across Kampung Kolam and Buckingham Street to further enhance the pedestrianised environment within the periphery of the pedestrian mall along Pitt Street and the community streets.

2.3 Pedestrian Crossing Facilities

At busy intersections and across 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 view point of pedestrian safety and the continuity of pedestrian accessibility.

Figure 2.3.1 illustrates the existing locations in the urban area installed with pedestrian crossing facilities such as the signalized crosswalk. Other locations where pedestrian crossing facilities are necessary are also shown. Priority measures for pedestrian crossings 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

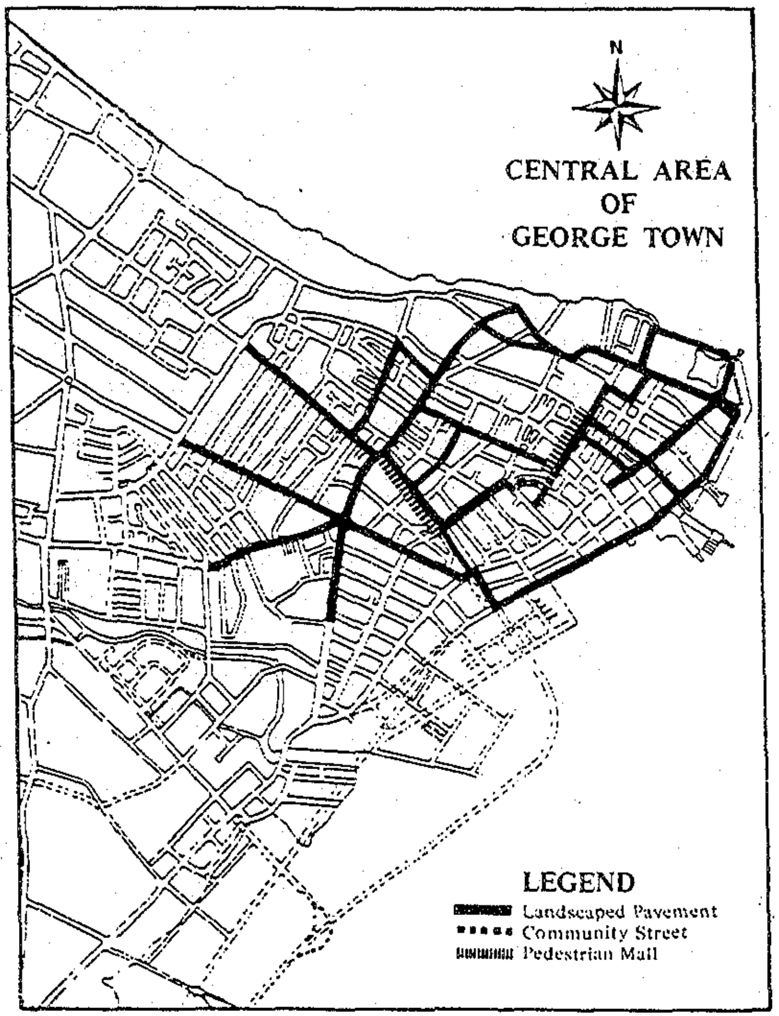


Figure 2.2.4 : Types Of Pedestrian Sidewalk In The Network

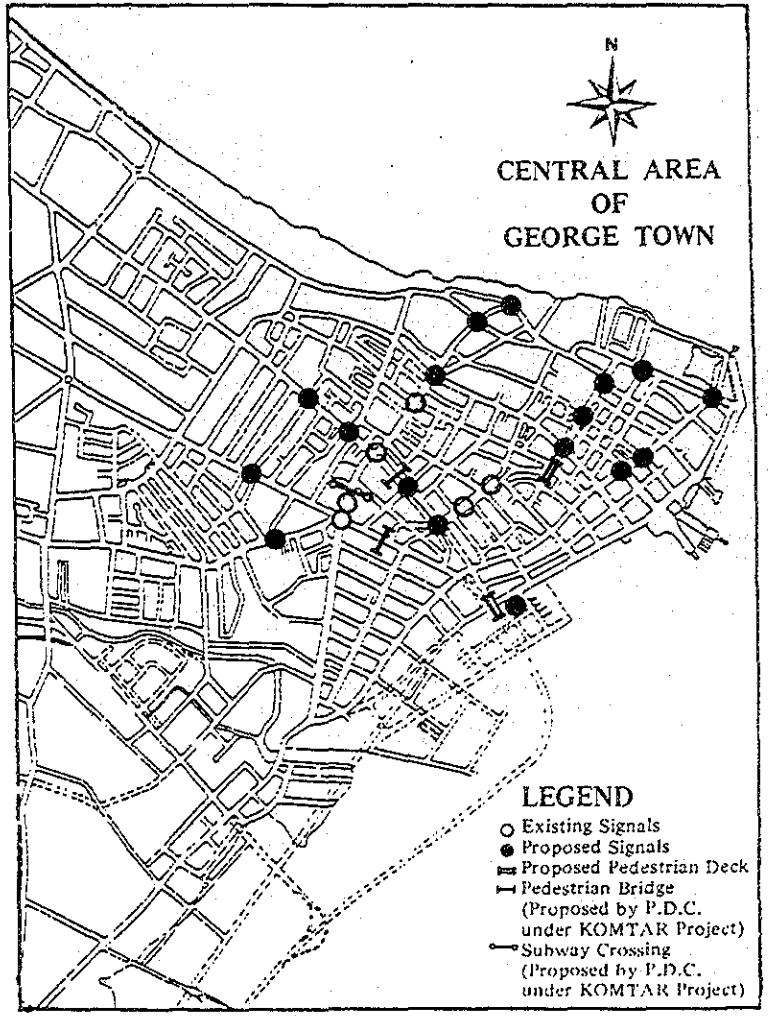


Figure 2.3.1 : Locations Installed With Pedestrian Crossing Facilities

3.0 PLANNING ASPECTS OF THE PEDESTRIAN PATH

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

3.1 Planning Considerations of the Sidewalk Width

Planning of pedestrian sidewalk width takes into consideration the number of lane of the carriageway and waiting/parking lane width (Figure 3.1.1). Determination of the carriageway lane number is based on the 'Traffic Assignment Under The Proposed TSM Plan, 2000'. Other pertinent factor includes consideration of the allowable existing road width. Generally, a minimum sidewalk width of 1.50 m is desirable in allowing a conducive and pleasant pedestrian movement.

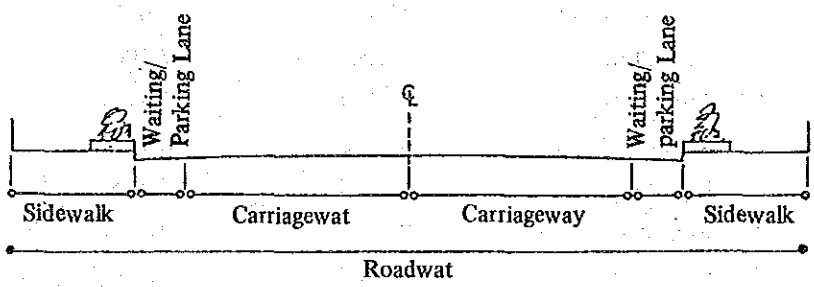


Figure 3.1.1 : Typical Cross-Section Of A Roadway

A. Determination of the Number of Traffic Lane

The number of traffic lane required on a particular roadway is derived from the following equation:

$$\text{Number of Lane Required} = \frac{\text{Traffic Volume (pcu/hour)}}{\text{Traffic Capacity (pcu/hour/lane)}}$$

where,

$$\text{Traffic Volume (pcu/hour)} = \text{Traffic Volume in Year 2000 (pcu/day)} \times \text{Peak Ratio (7\%)}$$

$$\text{Traffic Capacity (pcu/hour/lane)} = 1200$$

Table 3.1.1 : Number Of Traffic Lanes Along Major Roads In Central Area By The Year 2000

	Road Name	Traffic Volume In Year 2000 (pcu/day) (1)	Traffic Volume During Peak Hour (pcu/hour) (2)=(1)x7%	Number of Traffic Lane Required (3)=(2)÷1200
1.	Magazine Road	69,500	4,865	5
2.	Dato Keramat Road	58,900	4,123	4
3.	Penang Road	49,500	3,465	3
4.	Prangin Road	40,000	2,800	3 (4)b
5.	Farquhar Street	37,800	2,646	3 (4)a
6.	Burma Road	37,200	2,604	3
7.	Carnarvon Street	37,000	2,590	3
8.	Macalister Road	31,100	2,177	3
9.	Light Street	26,500	1,855	3
10.	Weld Quay	24,200	1,694	3 (4)a
11.	Pitt Street	21,200	1,484	2
12.	Beach Street	8,400	588	2

Note : a. Provision of 2 traffic lanes on one side in the case of 4 lanes carriageway.
b. Provision of a bus lane in the case of 4 lanes carriageway
c. Traffic Volume based on 'Traffic Assignment Under The Proposed TSM Plan, 2000'

B. Carriageway Width

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

C. Waiting/Parking Lane Width

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

Consequently, the sidewalk width could only be decided after having pre-determined the carriageway and waiting/parking lane width. Preferably, the height of the sidewalk kerb (kerbstone) from the adjoining carriageway would be between 150mm and 225mm.

3.2 Concepts of the Pedestrianisation Improvement Measures

A. Pedestrianisation Amenities

Careful and sensitive approach to design and co-ordinate planning of pedestrianisation amenities would add immesurably to the quality of the urban townscape. Table 3.2.1 is a list of the basic pedestrianisation amenities and their respective features. Illustrations of the street furnitures are presented in Figure 3.2.1.

Table 3.2.1 : Basic Pedestrianisation Amenities

Basic Amenities		Features
1.	*Street Furnitures*	
a.	Trash Receptacle	. To maintain cleaniness of urban scenes . To instill 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.	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 inter-*sections 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 city landmarks* . Serve as a means of effective communication in the urban area
f.	Benches	. A public and free leisure facilities . Allow the people to enjoy street views.
2.	***Sidewalk Paving Blocks***	
a.	Concrete Blocks	. Requiring negligible maintenance . Durable and safe surface . Low-cost
b.	Interlocking Block	. Brighten up the outdoor environment with their subtle colours and textures . Durable and safe surface (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**	. 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

B. **Basic Concept of Improvement Measure**

A pleasant pedestrianised environment adds to the quality of life in the city. Elements contributing to such quality includes an adequate and appropriate street furniture and public utility at suitable locations, improvement of pedestrian sidewalk lighting, and with a touch of greenery to the sidewalk. These elements are incorporated as part of the improvement measure for the proposed pedestrian network. Figure 3.2.2 shows the proposed pedestrianisation improvement plan along Pitt Street, the periphery of Armenian Street/Cannon Street/Cannon Square; and the pedestrian deck across Kampung Kolam and Buckingham Street.

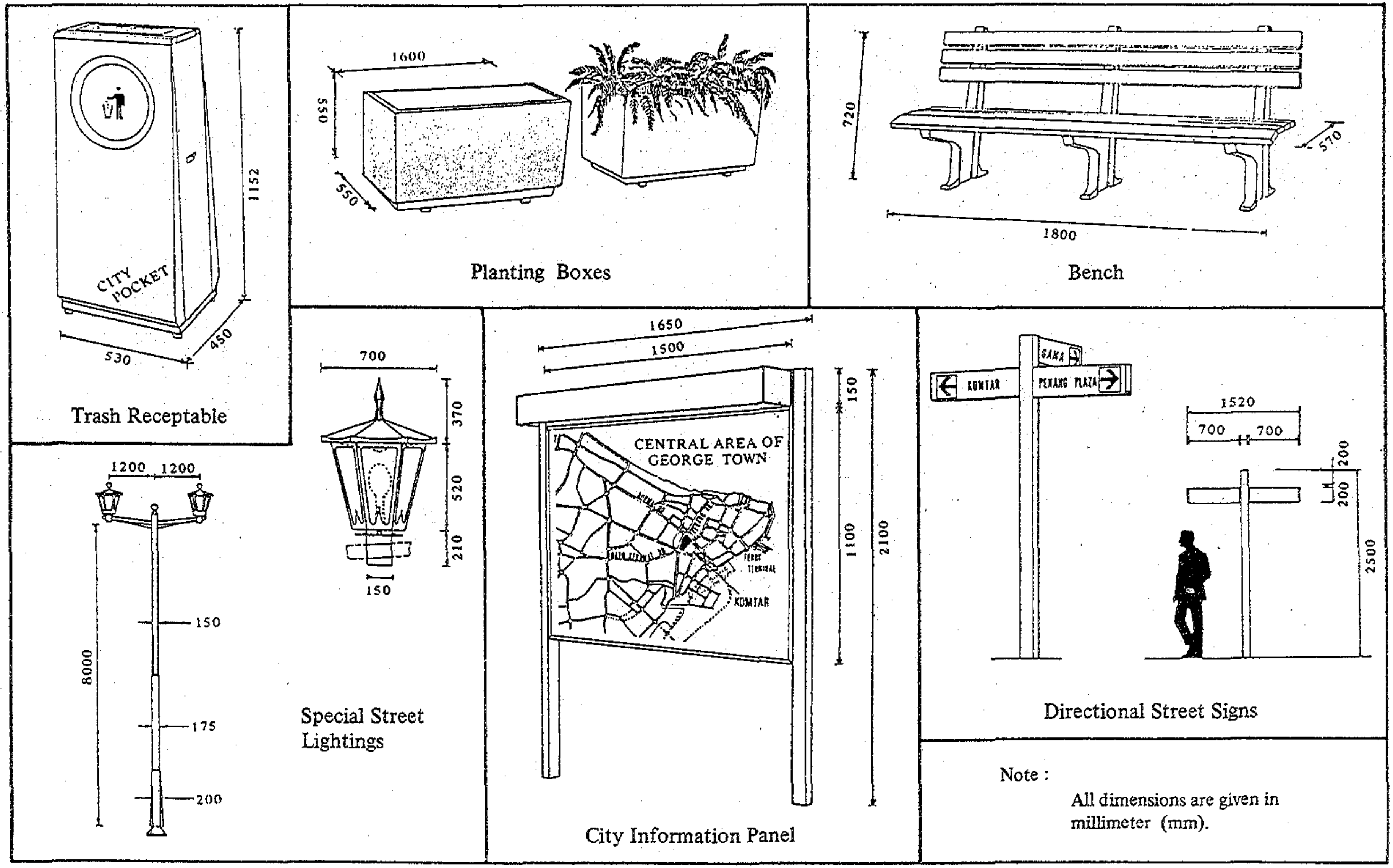


Figure 3.2.1 : Illustrative Concept Of The Street Furnitures Proposed For The Pedestrian Network

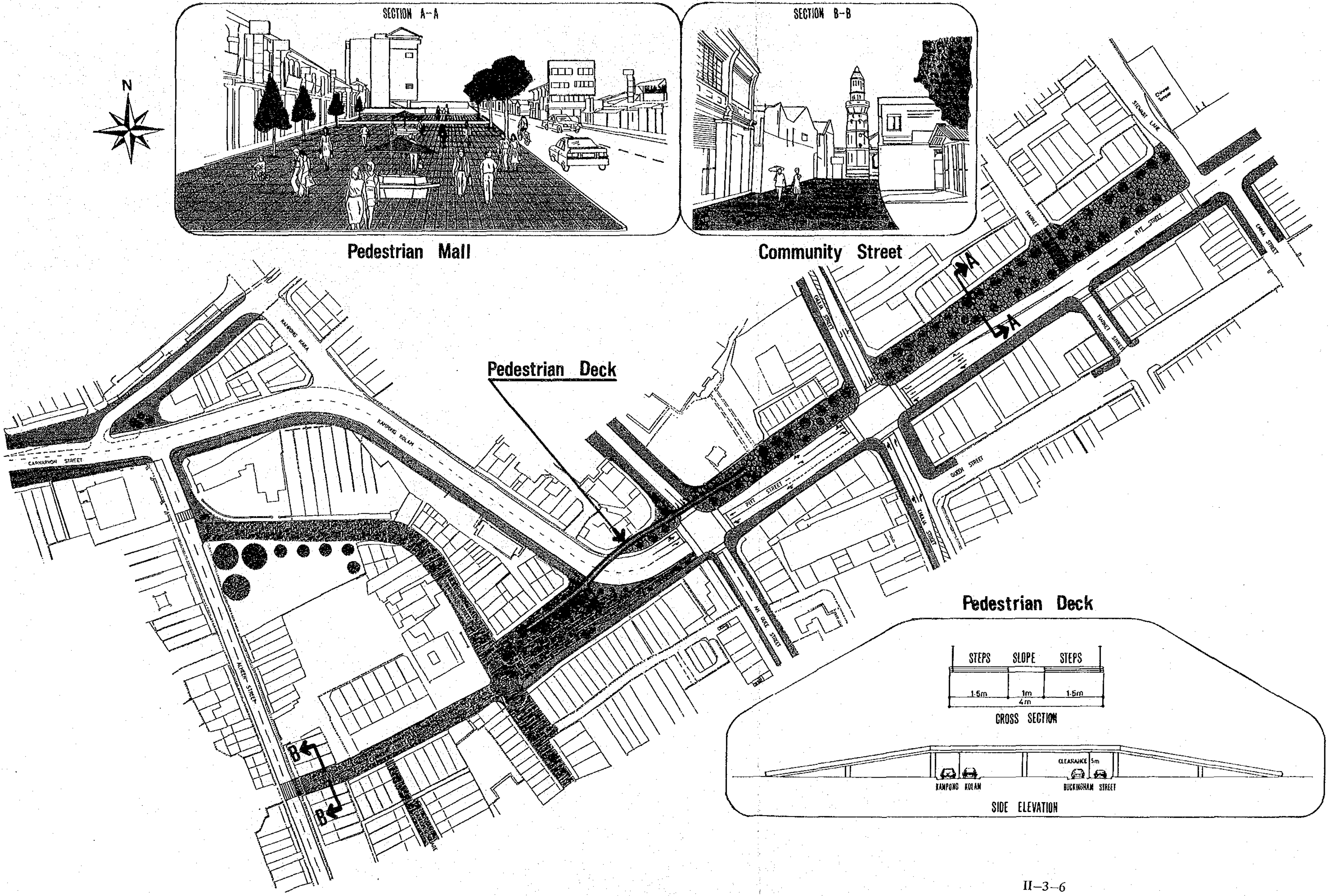


Figure 3.2.2 : Pedestrianisation Improvement Plan Along Pitt Street And Its Periphery
(Pedestrian Mall & Community Street)

Table 3.2.2 presents the road names in the pedestrian network in affiliation to the pedestrianisation improvement scheme. Cross-sectional views of these road sections are illustrated in the following figures.

Table 3.2.2 : Roadway Sections Proposed For The Pedestrianisation Improvement Plan

1. Argyll Road & Transfer Road
   (Between Penang Road & Burma Road)
2. Beach Street
   (Between Chulia Street & Light Street)
3. Brick Kiln Road
   (Between Magazine Circus & Kg Java Bahru)
4. Buckingham Street & Campbell Street
   (Between Pitt Street & Penang Road)
5. Burma Road
   (Between Anson Road & Penang Road)
6. Carnarvon Street to King Street
   (Via Armenian Street, Cannon Street, & Pitt Street)
7. China Street & China Street Ghaut
   (Between Pitt Street & Weld Quay)
8. Cintra Street & Sungai Ujong Road
   (Between Campbell Street & Prangin Road)
9. Dato Keramat Road
   (Between Penang Road & Siam Road)
10. Farquhar Street & Light Street
    (Between Penang Road & Beach Street)
11. Macalister Road
    (Between Anson road & Penang Road)
12. Magazine Road
    (Between Bridge Street & Magazine Circus)
13. Market Street & Market Street Ghaut
    (Between Pitt Street & Weld Quay–
14. Penang Road
    (Between Farquhar Street & Magazine Circus)
15. Prangin Road
    (Between Penang Road & Beach Street)
16. Weld Quay
    (Between Light Street & Prangin Street Ghaut)

Road Name	Argyll Road & Transfer Road (Between Penang Road & Burma Road)
Road Width (m)	9.0 – 12.0
Road Length (m)	715.0

Improvement Plan

Section A (Between Penang Road & Transfer Road)

a. Function
- . Section designated as a secondary pedestrian pathway
- . Carriageway serves as a local road

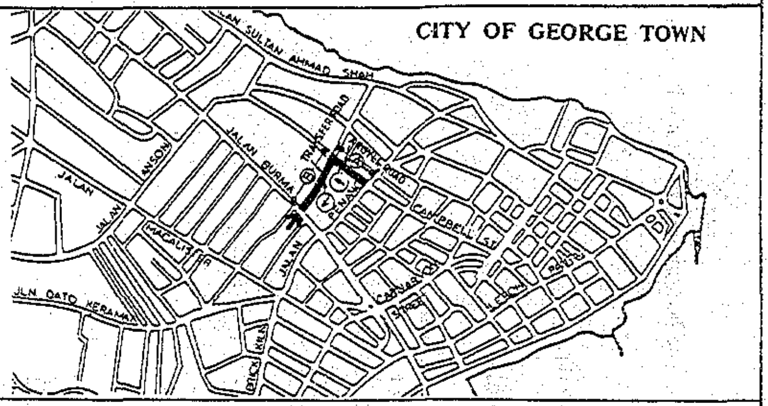
b. Proposal
- . Provision of street furniture such as city information panel, directional street sign, bus-stop with shelter, trash receptable.
- . Improve lighting of pedestrian sidewalk
- . Prohibition of on-street parking

Section B (Between Argyll Road & Burma Road)

a. Function
- . Section designated as a secondary pedestrian pathway
- . Carriageway serves as a local road

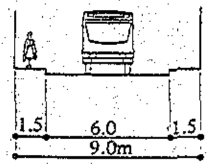
b. Proposal
- . Provision of street furniture such as city information panel, directional street sign, bus-stop with shelter, trash receptable
- . Improve lighting of pedestrian sidewalk
- . Prohibition of on-street parking

Location Map



Cross Section

Section A



Section B

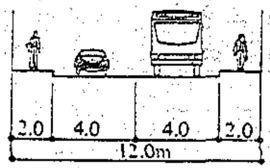


Figure 3.2.3 : Pedestrianisation Improvement Plan (1) – Argyll Road & Transfer Road

Road Name	Beach Street (Between Chulia Street & Light Street)
Road Width (m)	18.0
Road Length (m)	664

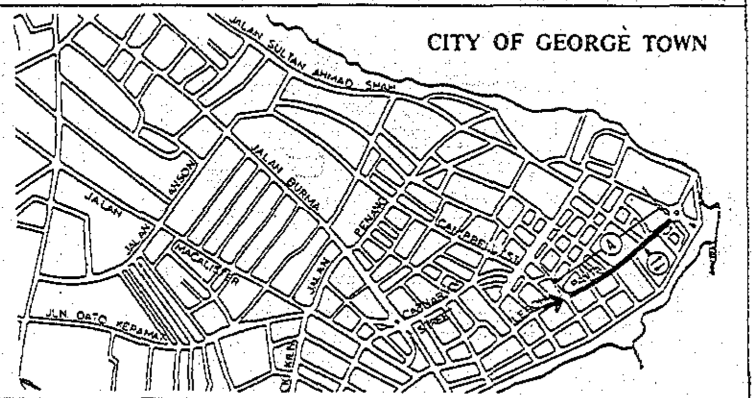
Improvement Plan

Section A (Between Chulia Street & Light Street)

a. Function
- Section designated as a secondary pedestrian pathway
- Carriageway serves as a local road

b. Proposal
- Provision of street furniture such as city information panel, street directional sign, trash receptable, street lighting
- Plant trees or shrubs on sidewalk
- Improve lighting of pedestrian sidewalk
- Provision of public utility such as telephone kiosk
- Prohibition of on-street parking
- Provision of car waiting lane on both flanks of carriage-way (1.5m)

Location Map



Cross Section

Section A

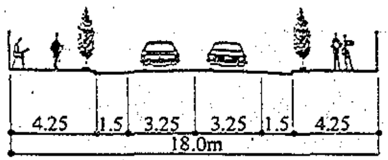


Figure 3.2.3 : Pedestrianisation Improvement Plan (2) – Beach Street

Road Name	Brick Kiln Road (Between Magazine Circus & Kampung Jawa Baharu)
Road Width (m)	17.0
Road Length (m)	431.3

Improvement Plan

Section A (Between Magazine Circus & Macallum Street)

a. Function
- Section designated as a secondary pedestrian pathway
- Carriageway serves as a primary road

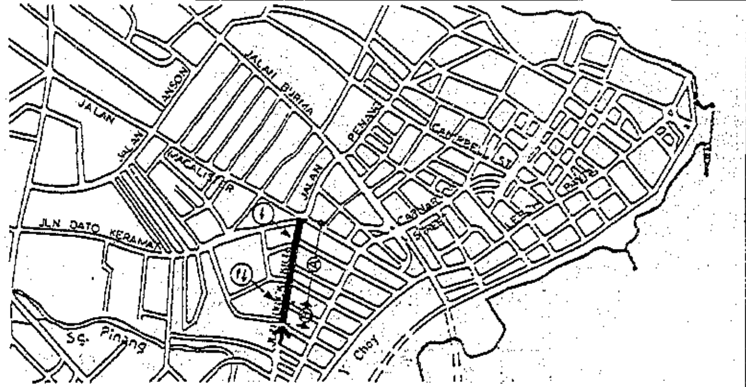
b. Proposal
- Provision of street furniture such as city information panel, directional street sign, trash receptable
- Flower box on sidewalk greater than 3.0 m wide
- Improve lighting of pedestrian sidewalk
- Provision of single side parking

Section B (Between Macallum Street & Kampong Java Baharu)

a. Function
- Section designed as a secondary pedestrian pathway
- Carriageway serves as a primary road

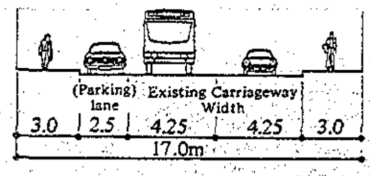
b. Proposal
- Provision of street furniture such as city information panel, directional *street sign, trash receptable*
- Flower box on sidewalk greater than 3.0 m wide
- Improve lighting of pedestrian sidewalk
- Provision of single side parking

Location Map



Cross Section

Section A



One Way

Section B

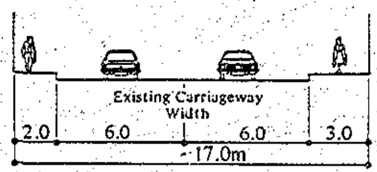


Figure 3.2.3 : Pedestrianisation Improvement Plan (3) – Brick Kiln Road

Road Name	Buckingham Street & Campbell Street (Between Pitt Street & Penang Road)
Road Width (m)	12.0
Road Length (m)	664

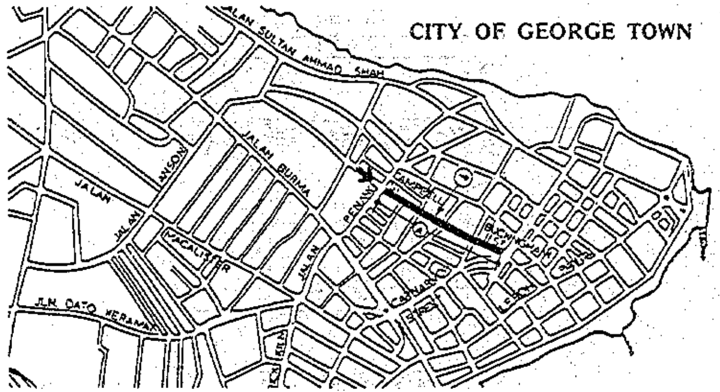
Improvement Plan

Section A (Between Penang Road & Pitt Street)

a. Function
- Section designated as a secondary pedestrian pathway
- Carriageway serves as a local road

b. Proposal
- Provision of street furniture such as city information panel, trash receptable, directional street sign
- Provision of public utility such as telephone kiosk
- Provision of single side parking
- Proposed one way traffic flow

Location Map



Cross Section

Section A

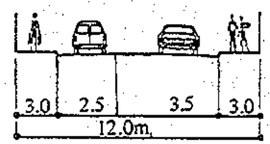


Figure 3.2.3 : Pedestrianisation Improvement Plan (4) – Buckingham Street & Campbell Street

Road Name	Burma Road (Between Anson Road & Penang Road)
Road Width (m)	15.35 – 16.95
Road Length (m)	815.0

Improvement Plan

Section A (Between Anson Road & Lorong Selamat)

a. Function
- Section designated as a primary pedestrian pathway
- Carriageway serves as a district road

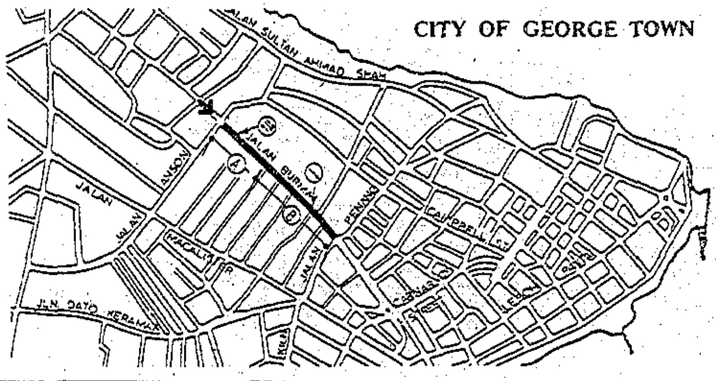
b. Proposal
- Provision of street furniture such as city information panel, directional street sign, trash receptable, bus stop with shelter, planting boxes
- Plant trees or shrubs on sidewalk greater than 3.5 m wide
- Improve lighting of pedestrian sidewalk
- Prohibition of on-street parking

Section B (Between Lorong Selamat & Penang Road)

a. Function
- Section designated as a primary pedestrian pathway
- Carriageway serves as a district road

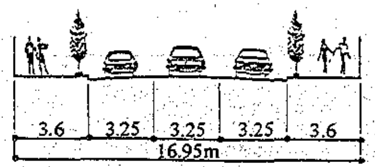
b. Proposal
- Provision of street furniture such as city information panel, directional street sign, trash receptable, bus stop with shelter
- Prohibition of on-street parking
- Provision of 3-lane one way traffic

Location Map



Cross Section

Section A



Section B

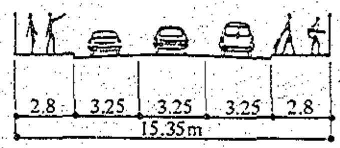


Figure 3.2.3 : Pedestrianisation Improvement Plan (5) – Burma Road

Road Name	Carnarvon Street to King Street Via Armenian Street, Cannon Street and Pitt Street
Road Width (m)	8.0 – 31.0
Road Length (m)	1379

Improvement Plan

Section A (Between Prangin Road & Leboh Acheh)

a. Function
- . Section designated as a primary pedestrian pathway
- . Carriageway serves as a district road

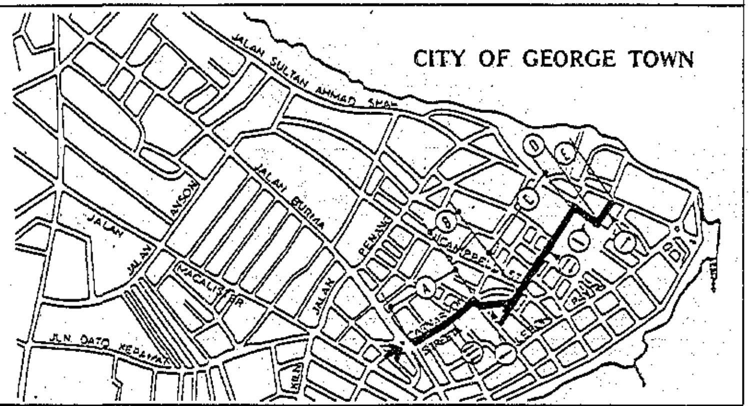
b. Proposal
- . Provision of street furniture such as city information panel, directional street sign, trash receptable, bus-stop with shelter, planting boxes
- . Plant trees or shrubs on sidewalk greater than 3.5m wide
- . Improve lighting of pedestrian sidewalk
- . Prohibition of on-street parking
- . Provisionof 3-lane one way traffic

Section B (Between Leboh Acheh & Kampung Kolam)

a. Function
- . Section designated as a primary pedestrian pathway
- . Carriageway serves as a community street

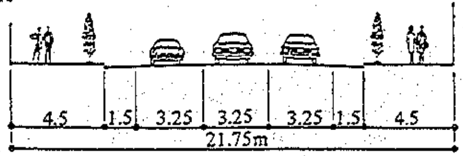
b. Proposal
- . Propose conversion of Armenian Street (Between Leboh Acheh & Cannon Street) and Cannon Street (Between Lebuh Acheh & Armenian Street) into community streets
- . Provision of street furniture such as city information panel, trash receptable, planting boxes, street lighting
- . Plant trees or shrubs on sidewalk
- . Improve lighting of pedestrian sidewalk
- . Provision of single side parking for the community car only

Location Map



Cross Section

Section A



Section B

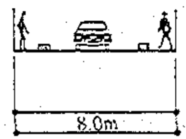


Figure 3.2.3 : Pedestrianisation Improvement Plan (6) – Carnarvon St. to King St. Via Armenian St., Cannon St. & Pitt St.

Road Name	Carnarvon Street to King Street Via Armenian Street, Cannon Street and Pitt Street
Road Width (m)	8.0 – 31.0
Road Length (m)	1379

Improvement Plan

Section C (Between Kampung Kolam & Bishop Street)

a. Function
- Section designated as a primary pedestrian pathway
- Carriageway serves as a district road

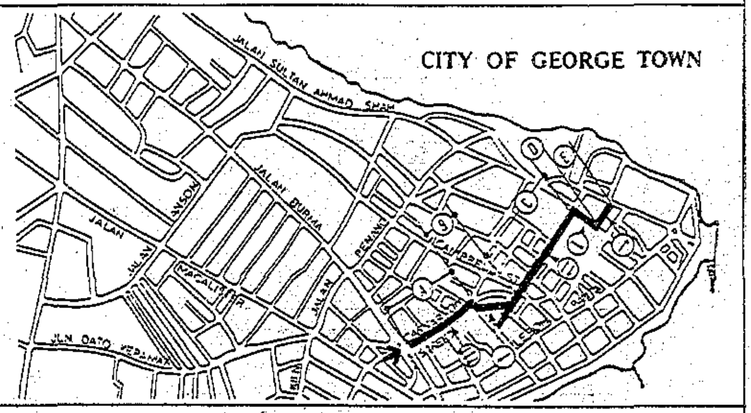
b. Proposal
- Propose conversion of the section between Buckingham Street & Stewart Lane into pedestrian mall
- Provision of street furniture such as city information panel, directional street sign, trash receptable, planting boxes, bus stop with shelter, bench, street lighting
- Provision of public utility such as telephone kiosk
- Plant trees or shrubs on sidewalk
- Improve lighting of pedestrian sidewalk
- Prohibition of on-street parking

Section D (Between Pitt Street & King Street)

a. Function
- Section designated as a primary pedestrian pathway
- Carriageway serves as a local road

b. Proposal
- Provision of street furniture such as city information panel, trash receptable
- Provision of single side parking only (2.0 m)

Location Map



Cross Section

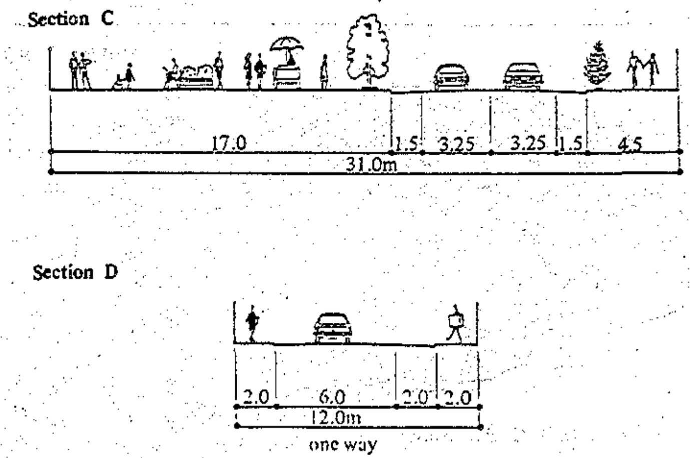


Figure 3.2.3 : Pedestrianisation Improvement Plan (7) – Carnarvon St. to King St. Via Armenian St., Cannon St. & Pitt St.

Road Name	Carnarvon Street to King Street Via Armenion Street, Cannon Street and Pitt Street
Road Width (m)	8.0 – 31.0
Road Length (m)	1379

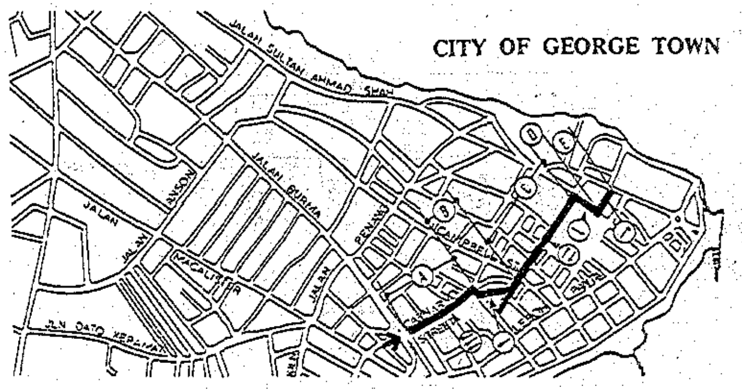
Improvement Plan

Section E (Between Bishop Street & Light Street)

a. Function
- Section designated as a primary pedestrian pathway
- Carriageway serves as a local road

b. Proposal
- Provision of street furniture such as street directional sign, trash receptable, street lighting
- Plant trees or shrubs on sidewalk
- Improve lighting of pedestrian sidewalk
- Provision of public utility such as telephone kiosk
- Provision of parking on both flanks of carriageway

Location Map



Cross Section

Section E

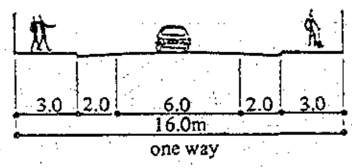


Figure 3.2.3 : Pedestrianisation Improvement Plan (8) – Carnarvon St. to King St. Via Armenian St., Cannon St. & Pitt St.

Road Name	China Street & China Street Ghaut (Between Pitt Street & Weld Quay)
Road Width (m)	10.0 – 18.0
Road Length (m)	560

Improvement Plan

Section A (Between Pitt Street & Beach Street)

a. Function
- . Section designated as a secondary pedestrian pathway
- . Carriageway serves as a local road

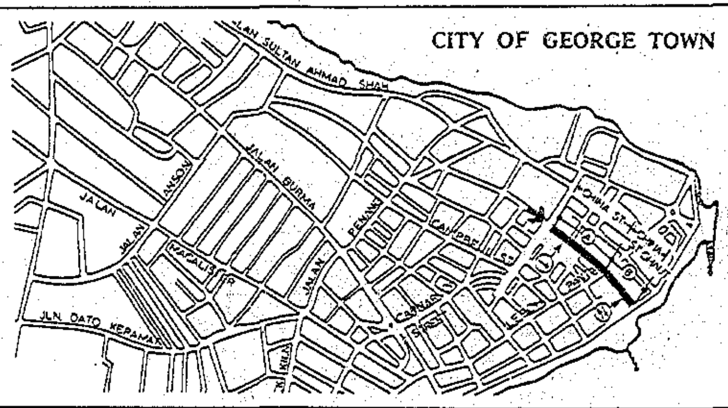
b. Proposal
- . Provision of street furniture such as directional street sign, trash receptable
- . Improve lighting of pedestrian sidewalk
- . Prohibition of on-street parking

Section B (Between Beach Street & Weld Quay)

a. Function
- . Section designated as a secondary pedestrian pathway
- . Carriageway serves as a local road

b. Proposal
- . Provision of street furniture such as city information panel, directional street sign, trash receptable, bench, planting boxes
- . Plant trees or shrubs on sidewalk
- . Improve lighting of pedestrian sidewalk
- . Provision of single side parking only

Location Map



Cross Section

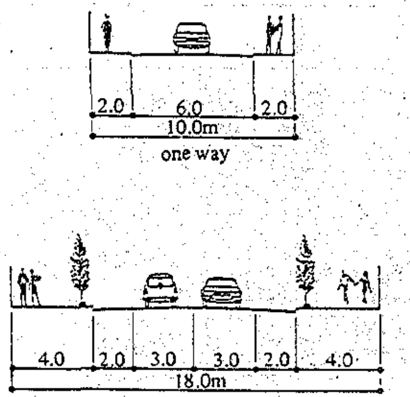


Figure 3.2.3 : Pedestrianisation Improvement Plan (9) – China St. & China St. Ghaut

Road Name	Cintra Street & Sungai Ujong Road (Between Campbell Street & Prangin Road)
Road Width (m)	10.0
Road Length (m)	382.0

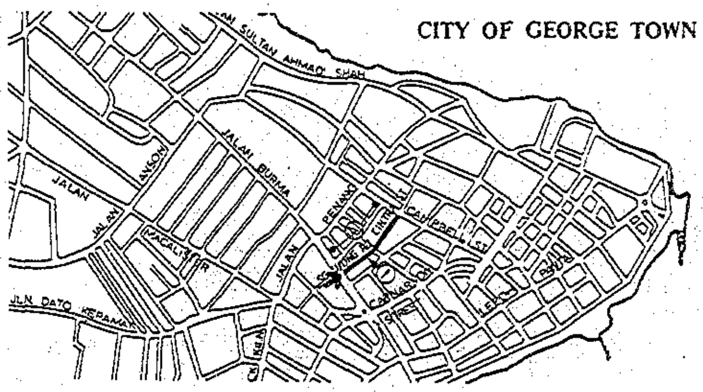
Improvement Plan

Section A (Between Prangin Road & Campbell Street)

a. Function
- . Section designated as a secondary pedestrian pathway
- . Carriageway serves as a local road

b. Proposal
- . Provision of street furniture such as city information panel, directional street sign, trash receptable, lighting
- . Plant-trees or shrubs on sidewalk
- . Improve lighting of pedestrian sidewalk
- . Prohibition of on-street parking

Location Map



Cross Section

Section A

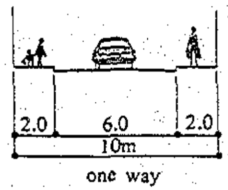


Figure 3.2.3 : Pedestrianisation Improvement Plan (10) – Cintra St. & Sungai Ujong Road

Road Name	Dato Keramat Road (Between Penang Road & New Lane)
Road Width (m)	19.0
Road Length (m)	978.0

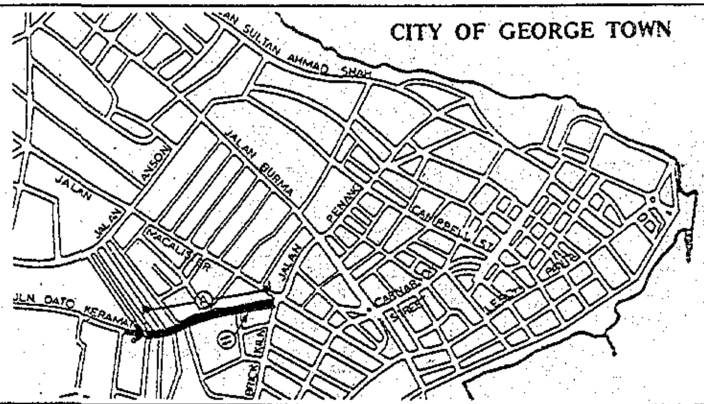
Improvement Plan

Section A (Between Penang Road & Siam Road)

a. Function
- . Section designated as a primary pedestrian pathway
- . Carriageway serves as a primary road.

b. Proposal
- . Provision of city information panel in front of Gama Department Store
- . Provision of public utility such as telephone kiosk
- . Prohibition of on-street parking
- . Provision of 4-lane carriageway

Location Map



Cross Section

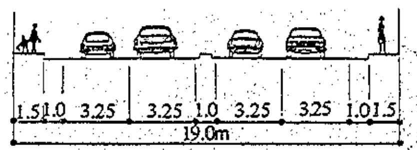


Figure 3.2.3 : Pedestrianisation Improvement Plan (11) – Dato Keramat Road

Road Name	Farquhar Street & Light Street (Between Penang Road & Beach Street)
Road Width (m)	9.0 – 18.5
Road Length (m)	1166

Improvement Plan

Section A (Between Penang Road & Love Lane)

a. Function
- Section designated as a secondary pedestrian pathway
- Carriageway serves as a primary road

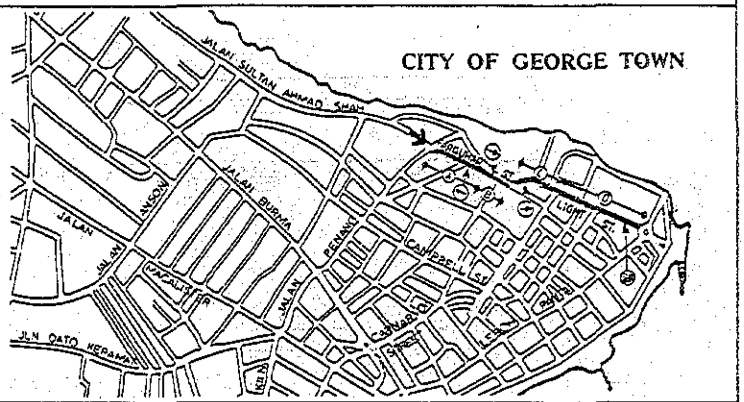
b. Proposal
- Provision of street furniture such as city information panel, directional street sign, trash receptable, planting boxes
- Plant trees or shrubs on sidewalk
- Provision of public utility such as telephone kiosk
- Improve lighting of pedestrian sidewalk
- Prohibition of on-street parking

Section B (Between Love Lane & Light Street)

a. Function
- Section designated as a secondary pedestrian pathway
- Carriageway serves as a primary road

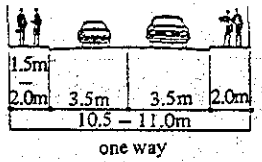
b. Proposal
- Provision of street furniture such as city information panel, directional street sign, trash receptable, planting boxes
- Plant trees or shrubs on sidewalk
- Improve lighting of pedestrian sidewalk
- Prohibition of on-street parking

Location Map



Cross Section

Section A



Section B

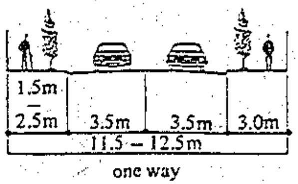


Figure 3.2.3 : Pedestrianisation Improvement Plan (12) – Farquhar St. & Light St.

Road Name	Farquhar Street & Light Street (Between Penang Road & Beach Street)
Road Width (m)	9.0 – 18.5
Road Length (m)	1166

Improvement Plan

Section C (Between Light Street & Pitt Street)

a. Function
- . Section designated as a secondary pedestrian pathway
- . Carriageway serves as a primary road

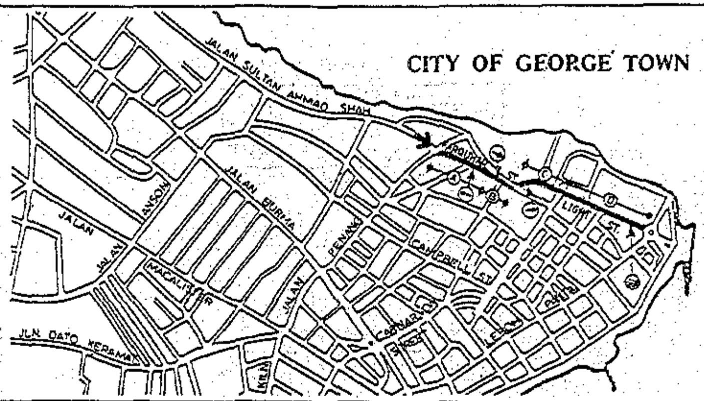
b. Proposal
- . Provision of street furniture such as city information panel, directional street sign, trash receptable
- . Plant trees or shrubs on sidewalk
- . Improve lighting of pedestrian sidewalk
- . Provision of single side parking (adjacent to Convent Light Street School)

Section D (Between Pitt Street & Beach Street)

a. Function
- . Section designated as a secondary pedestrian pathway
- . Carriageway serves as a primary road

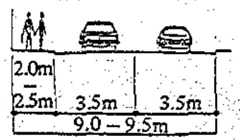
b. Proposal
- . Provision of street furniture such as city information panel, directional street sign, trash receptable
- . Improved lighting of pedestrian sidewalk
- . Prohibition of on-street parking

Location Map



Cross Section

Section C



Section D

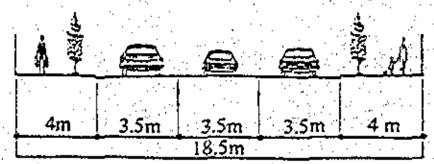


Figure 3.2.3 : Pedestrianisation Improvement Plan (13) – Farquhar St. & Light St.

Road Name	Macalister Road (Between Anson Road & Penang Road)
Road Width (m)	22.0
Road Length (m)	865.0

Improvement Plan

Section A (Between Anson Road & Yahudi Road)

a. Function
- Section designated as a primary pedestrian pathway
- Carriageway serves as a district road

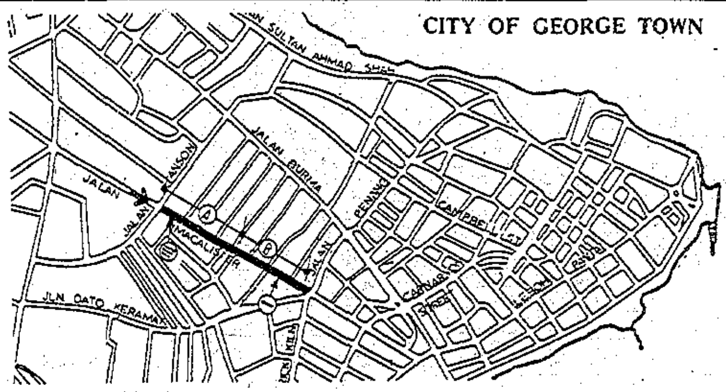
b. Proposal
- Provision of street furniture such as city information panel, trash receptable, bus stop with shelter, planting boxes
- Improve lighting of pedestrian sidewalk
- Plant trees or shrubs on sidewalk greater than 3.5 m wide
- Provision of three lanes with 2-lane approaching Anson Road
- Prohibition of on-street parking

Section B (Between Yahudi Road & Penang Road)

a. Function
- Section designated as a primary pedestrian pathway
- Carriageway serves as a district road

b. Proposal
- Provision of street furniture such as city information panel, trash receptable, bus stop with shelter, planting boxes
- Plant trees or shrubs on sidewalk greater than 3.5 m wide
- Provision of 3-lane one way traffic
- Prohibition of on-street parking

Location Map



Cross Section

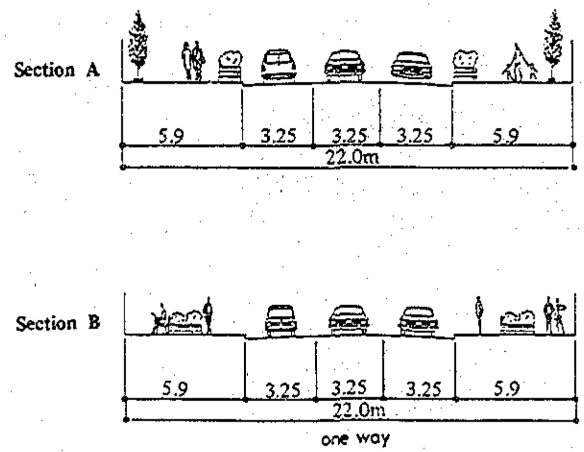


Figure 3.2.3 : Pedestrianisation Improvement Plan (14) – Macalister Road

Road Name	Magazine Road (Between Penang Road & Bridge Street)
Road Width (m)	17.0
Road Length (m)	533.0

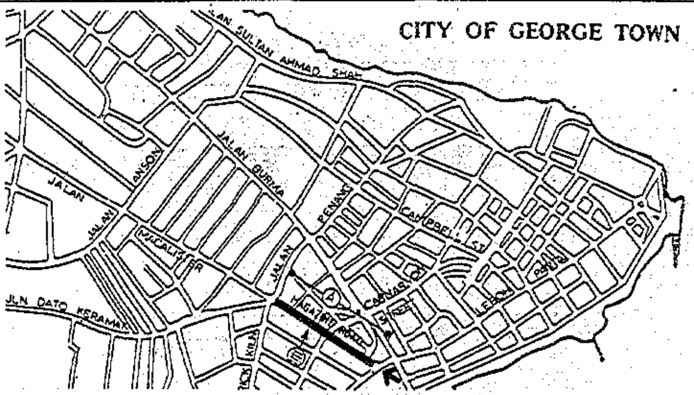
Improvement Plan

Section A (Between Penang Road & Bridge Street)

a. Function
- Section designated as a primary pedestrian pathway
- Carriageway serves as a primary road

b. Proposal
- Provision of street furniture such as city information panel, directional street sign, trash receptable, bus-stop with shelter
- Adjacent side to KOMTAR is incorporated with KOMTAR Pedestrianisation Project
- Improve street lighting of pedestrian sidewalk
- Provision of a 5-lane one way traffic
- Prohibition of on-street parking

Location Map



Cross Section

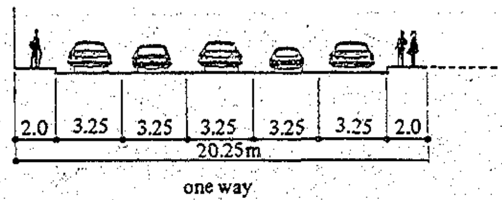


Figure 3.2.3 : Pedestrianisation Improvement Plan (15) – Magazine Road

Road Name	Market Street & Market Street Ghaut (Between Pitt Street & Weld Quay)
Road Width (m)	10.0 – 16.0
Road Length (m)	543

Improvement Plan

Section A (Between Pitt Street & Beach Street)

a. Function
- Section designated as a secondary pedestrian pathway
- Carriageway serves as a local road

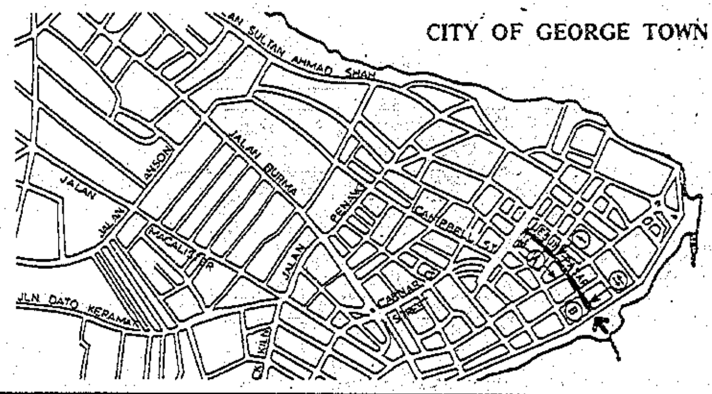
b. Proposal
- Provision of street furniture such as city information panel, directional street sign, trash receptable, plant boxes
- Plant trees or shrubs on sidewalk
- Improve street lighting of pedestrian sidewalk
- Provision of public utility such as telephone kiosk
- Prohibition of on-street parking

Section B (Between Victoria Street & Weld Quay)

a. Function
- Section designated as a secondary pedestrian pathway
- Carriageway serves as a local road

b. Proposal
- Provision of street furniture such as city information panel directional street sign, trash receptable, plant boxes
- Plant trees or shrubs on sidewalk
- Improve street lighting of pedestrian sidewalk
- Provision of public utility such as telephone kiosk
- Prohibition of on-street parking (Allow provision for existing bus terminal only)

Location Map



Cross Section

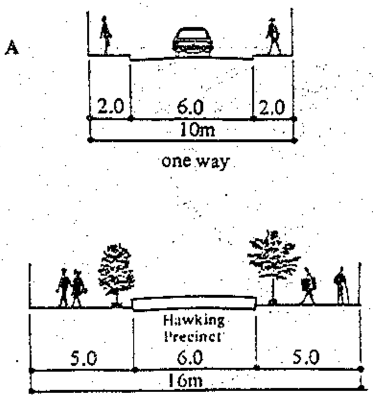
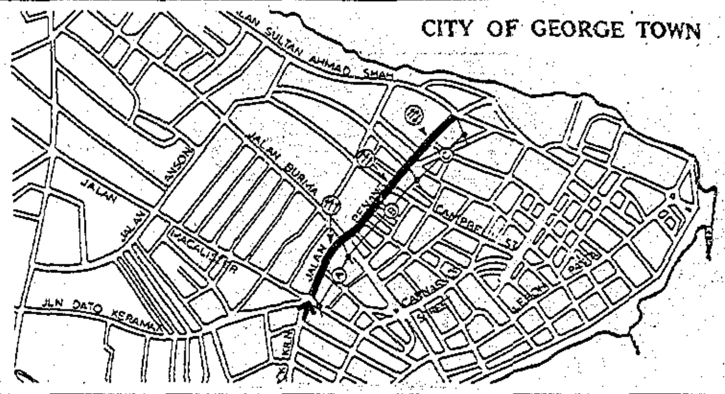


Figure 3.2.3 : Pedestrianisation Improvement Plan (16) – Market St. & Market St. Ghaut

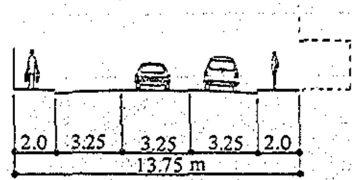
Road Name	Penang Road (Between Farquhar Street & Macalister Road)
Road Width (m)	13.75 – 21.0
Road Length (m)	1136

Location Map

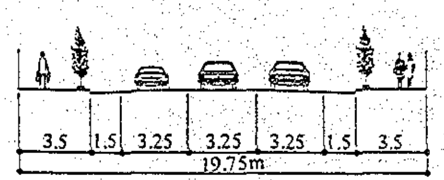


Cross Section

Section A



Section B



Improvement Plan

Section A (Between Macalister Road & Burma Road)

a. Function
- Section designated as a primary pedestrian pathway
- Carriageway serves as a primary road

b. Proposal
- Provision of street furniture such as city information panel, directional street sign, trash receptable, bus stop with shelter
- Adjacent side to KOMTAR is incorporated with KOMTAR Pedestrianisation Project
- Prohibition of on-street parking
- Provision of 3-lane one way traffic

Section B (Between Burma Road & Chulia Street)

a. Function
- Section designated as a primary pedestrian pathway
- Carriageway serves as a district road

b. Proposal
- Provision of street furniture such as city information panel, directional street sign, trash receptable, bus stop with shelter
- Plant trees or shrubs on sidewalk greater than 3.5m wide
- Improve lighting of pedestrian sidewalk
- Prohibition of on-street parking
- Provision of one way traffic in the reverse direction to the existing one upon completion of the impending Coastal Road
- Provision of waiting lane (1.5 m on both carriageway flanks)

Figure 3.2.3 : Pedestrianisation Improvement Plan (17) – Penang Road

Road Name	Penang Road (Between Farquhar Street & Macalister Road)
Road Width (m)	13.75 – 21.0
Road Length (m)	1136

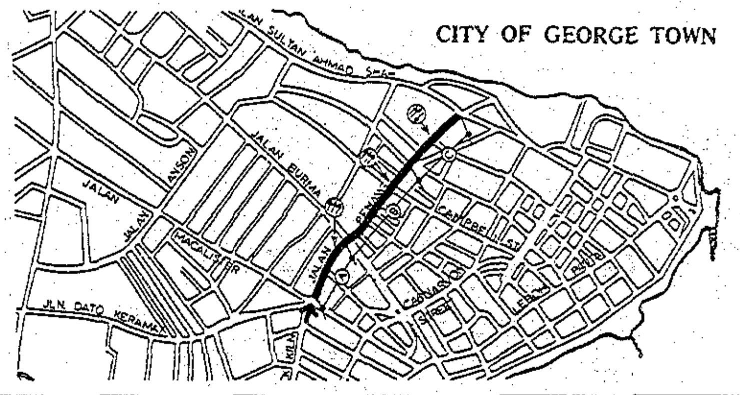
Improvement Plan

Section C (Between Chulia Street & Farquhar Street)

a. Function
- Section designated as a primary pedestrian pathway
- Carriageway serves as a district road

b. Proposal
- Provision of street furniture such as city information panel, directional street sign, trash receptable, bench
- Plant trees or shrubs on sidewalk greater than 3.5 m wide
- Improve lighting of pedestrian sidewalk
- Prohibition of on-street parking
- Provision of waiting lane (1.5 m on both carriageway flanks)

Location Map



Cross Section

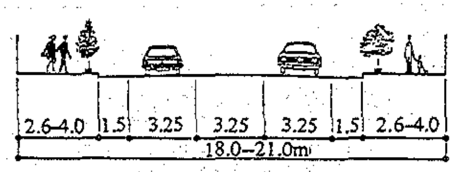


Figure 3.2.3 : Pedestrianisation Improvement Plan (18) – Penang Road

Road Name	Prangin Road (Between Penang Road & Carnarvon Street)
Road Width (m)	18.0
Road Length (m)	432.0

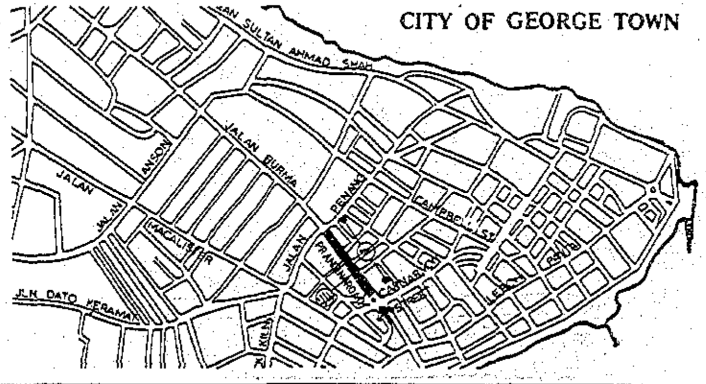
Improvement Plan

Section A (Between Penang Road & Carnarvon Street)

a. Function
- . Section designated as a primary pedestrian pathway
- . Carriageway serves as a primary road

b. Proposal
- . Propose a pedestrian mall along entire stretch of Section A adjacent to KOMTAR
- . Provision of street furniture such as city information panel, directional street sign, trash receptable, bench, planting boxes
- . Plant trees or shrubs on sidewalk
- . Provision of public utility eg. telephone kiosk
- . Improve lighting of pedestrian sidewalk
- . Prohibition of on-street parking
- . Provision of 4-lane one way traffic

Location Map



Cross Section

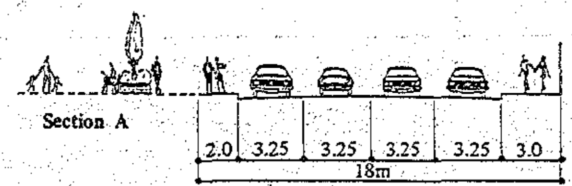


Figure 3.2.3 : Pedestrianisation Improvement Plan (19) – Prangin Road

Road Name	Weld Quay (Between Prangin Street Ghaut & Light Street
Road Width (m)	18 – 22
Road Length (m)	1,045.0

Improvement Plan

Section A (Between Prangin Street Ghaut & Ferry Terminal)

a. Function
- Section designated as a secondary pedestrian pathway
- Carriageway serves as a primary road

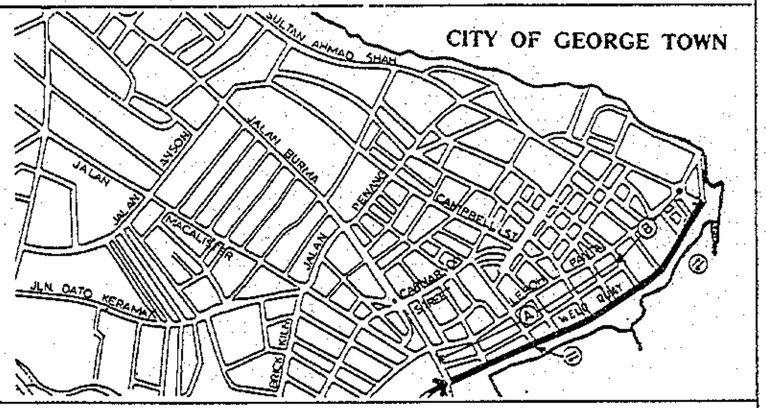
b. Proposal
- Provision of street furniture such as city information panel, directional street sign, bus-stop with shelter, trash receptable
- Plant trees or shrubs on sidewalk
- Improve lighting of pedestrian sidewalk
- Provision of public utility such as telephone kiosk
- Prohibition of on-street parking

Section B (Between Ferry Terminal & Light Street)

a. Function
- Section designated as a secondary pedestrian pathway
- Carriageway serves as a primary road

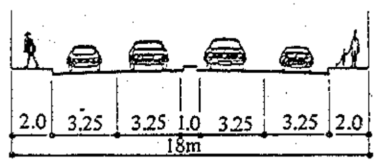
b. Proposal
- Provision of street furniture such as city information panel, directional street sign, bus-stop with shelter, trash receptable
- Plant trees or shrubs on sidewalk
- Improve lighting of pedestrian sidewalk
- Provision of public utility such as telephone kiosk
- Prohibition of on-street parking

Location Map



Cross Section

Section A



Section B

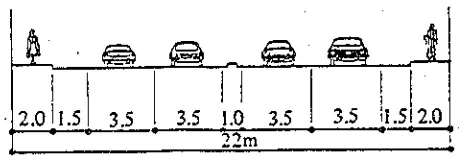


Figure 3.2.3 : Pedestrianisation Improvement Plan (20) – Weld Quay

4.0 IMPLEMENTATION

The proposed pedestrian path network shall be implemented in stages. Basically, the implementation should begin on road sections with relative heavy pedestrian movement or where pedestrian footpath are non-existent or inadequate. In addition, the implementation should be undertaken in coordination with other T.S.M. measures (eg. parking control plan, one-way traffic circulation system, etc.).

4.1 Examination of The Ranking Order of Implementation

A. Basic Guidelines

The priority ranking order of implementation for the individual pathway in the network is based on the following guidelines:

1. **Existing Pedestrian Volume**

   A particular pathway is given a higher priority of implementation if its pedestrian volume is comparatively higher than the other pathway.

2. **Physical Conditions of the Existing Footpath**

   A particular pathway is given a higher priority of implementation if its existing paved footpath conditions is inadequate in accommodating the increasing pedestrian demand as compared to other pathway.

3. **Pedestrian Path Network Classification**

   Basically, the primary pathway are given a higher priority of implementation than the secondary pathways. The former provides essential linkage amongst the various core areas of diversified interest and activities along the major routes in the urban areas.

In short, the interplay of the above mentioned guidelines can be used to examine the relative urgency in implementing each individual pathway in the network.

B. Priority Ranking Order Of Implementation

Table 4.1.1 shows the priority ranking order of implementation of the pedestrian pathway. The hierarchy is based largely on the basic guidelines as described in the preceding section.

In the examination of the priority of implementation, 2 (two) sections of the pedestrian pathway have been excluded. The first section, namely, Macalister Road (between Magazine Circus and Anson Road) has been excluded as the MPPP had recently undertaken improvement works on the sidewalks along this road. The other section includes the periphery of the KOMTAR Project Zone (circumscribed by Penang Road/Maxwell Road/Prangin Road/Magazine Road).

Pedestrianisation improvement plan on these road sections would be undertaken as part of the future KOMTAR Project, and as such, is left to be proceeded thereafter. Though some of these road sections had been underlaid with pedestrian footpath (for instance, the pedestrian mall in front of Super KOMTAR), nevertheless, further expansion and improvement plans are desirable to bring about a more pleasant and a continuous pedestrian movement.

Table 4.1.1 : Priority Ranking Order Of Implementation

Road Name	Ranking Order
• Burma Road (Between Penang Road & Anson Road) • Dato Keramat Road (Between Penang Road & Siam Road)	1
• Pitt Street/Armenian Street/Cannon Street/ Cannon Square/Bishop Street/King Street • Market Street & Market Street Ghaut (Between Pitt Street & Weld Quay)	2
• Penang Road (Between Chulia Street & Farquhar Street) • Carnarvon Street (Between Carnarvon Circus & Acheh Street)	3
• Campbell Street & Buckingham Street (Between Penang Road & Pitt Street) • Sungai Ujong Road & Cintra Street (Between Prangin Road & Campbell Street) • Transfer Road & Argyll Road ** (Between Burma Road & Penang Road)	4
• Beach Street (Between Chulia Street & Light Street) • China Street & China Street Ghaut (Between Pitt Street & Weld Quay) • Weld Quay (Between Light Street & Prangin Streeet Ghaut) • Farquhar Street & Light Street * (Between Penang Road & Beach Street) • Brick Kiln Road * (Between Magazine Circus & Kg. Java Bahru)	5

Note : * Pedestrianisation amenities to improve the existing sidewalk image would be sufficient.
** Implementation would be undertaken in coordination and planning with the KOMTAR Project and other T.S.M. measures (eg. one-way traffic circulation system, etc.).

4.2 Cost Estimation of Pedestrian Path Network

The cost in implementing the pedestrian pathways is estimated from the construction and improvements on existing road sections. It includes the widening of the existing sidewalks and the replacement of the old concrete pavement with the new and colourful interlocking paving blocks.

A. Basis of Cost Estimation

The basis of cost estimation for the proposed path network is as follows :

1. Cost quoted in Malaysian dollars (M$).
2. Estimation based on unit cost as quoted by the end of July 1987.
3. Cost estimation based on the proposed plan for each road section.
4. The estimation excludes the cost of the pedestrian amenities (eg. the street furnitures, greenery, public utilities, etc.).

B. Unit Cost of Construction

As the cost of the pedestrian amenities is taken as optional, only the cost of the sidewalk paving blocks and the foreseeable civil works are presented (Table 4.2.1).

Table 4.2.1 : Unit Cost of Estimation

Item	Unit Cost (M$)
1. Sidewalk Paving Block	
a. Concrete Block	$17.92 per sq.m.
b. Interlocking Block	$46.00 per sq.m.
2. Kerbs	$19.68 per m
3. Drainage	
a. Culvert	$229.60 per m
b. Scuppers	$ 19.68 per m
c. Resiting of Drainage (12 ins)	$ 91.97 per m
d. Drainage Cover	$ 17.92 per sq.m.

Note : Unit cost as quoted by the end of July, 1987.

C. Estimated Improvement/Construction Cost

Cost estimation for the improvement/construction on each road section in the network is tabulated in Table 4.2.2. Total improvement/construction cost is estimated to be approximately M$3.81 million. The estimated cost excludes the cost for the pedestrian amenities such as street furnitures, public utilities (eg. telephone kiosk), greeneries (eg. trees and shrubs), etc.

Table 4.2.3 : Estimated Improvement/Construction Cost

		Road Name	Improvement/Construction Cost (M$)
PRIMARY PATHWAYS	1.	Burma Road	232,708
	2.	Dato Keramat Road	272,630
	3.	King Street/Bishop Street	82,447
	4.	Pitt Street/Armenian Street/Cannon Street/Cannon Square	551,785
	5.	Penang Road (Between Chulia Street & Farquhar Street)	155,381
	6.	Carnarvon Street	128,393
		Sub-Total M$	1,423,344
SECONDARY PATHWAYS	1.	Market Street/Market Street Ghaut	114,183
	2.	Campbell Street/Buckingham Street	243,786
	3.	Sungai Ujong Road/Cintra Street	134,917
	4.	China Street/China Street Ghaut	214,158
	5.	Beach Street	185,732
	6.	Farquhar Street/Light Street	424,736
	7.	Transfer Road/Argyll Road	197,699
	8.	Weld Quay	419,366
	9.	Brick Kiln Road	152,352
		Sub-Total M$	2,086,929
FUTURE KOMTAR PROJECT	1.	Penang Road (Between Magazine Circus & Chulia Street)	131,709
	2.	Prangin Road (Between Penang Road & Beach Street)	107,217
	3.	Magazine Road (Between Magazine Circus & Bridge Street)	63,477
		Sub-Total M$	302,403
		Total Cost Estimated M$	3,812,676

4.3 Implementation Programme And Other Considerations

A. Implementation Programme

The implementation would be carried out in two (2) stages. Both stages take into account the development of the other T.S.M. measures such as the one-way traffic circulation system, bus circulation system, in addition to the KOMTAR Project.

1. **Stage I (1988 – 1990)**

   Implementation would begin with pathways having higher priorities and is expected to be completed by the end of 1990. (Note: Stage I includes all the primary pathways).

2. **Stage II (1991–1995)**

   Implementation of all the pathways of lower priorities (specifically, the secondary pathways) begins upon the completion of the Stage I pathways and is expected to be completed by the end of 1995.

   With due considerations to the list of priority for implementation (Table 4.1.1), the schedule is drawn up as shown in Table 4.3.1.

Table 4.3.1 : Implementation Programme

	Year / Road Name	1988	1989	1990	1991–1995	
STAGE 1 PATHWAYS	1. Burma Road	—				
	2. Dato Keramat Road	—				
	3. King Street/Bishop Street	—				
	4. Pitt Street/Armenian Street/ Cannon Street/Cannon Square		—			
	5. Market Street & Market Street Ghaut			—		
	6. Penang Road (Between Chulia Street/Farquhar Street)			—		
	7. Carnarvon Street			—		
	STAGE II PATHWAYS				—	Total
	Cost, Million (M$)	0.59	0.55	0.40	2.27	3.81

B. **Other Considerations Prior To Implementation**

The following points need to be taken into consideration prior to the implementation of a pedestrian pathway :

1. **Detail Design of Pedestrian Pathway**

   In this study, the pedestrian pathway designs are solely conceptual; consequently, a detail design should be prepared prior to implementation. The implementation should be undertaken in coordination with the other traffic engineering measures. Careful and sensitive approach to design and planning of pedestrianisation amenities on pedestrian pathway should be adopted.

2. **Location of Street Furniture**

   For the pathways which are wide as for a pedestrian mall, street furnitures should be located whereby the entry and movement of vehicles (e.g. ambulance, fire engines) during an emergency would not be restricted or confined.

   Whereas, for the narrow pathways, street furnitures should be located such that a minimum width of 1.50 m is allowed to ensure a smooth and pleasant pedestrian access.

3. **Pedestrian Crossing Facilities**

   Pedestrian crossing facilities should be installed in coordination with the implementation of pedestrian pathways. By virtues, at signalized intersections in the urban areas, pedestrian crossing facilities are installed. However, at non-signalised intersections or along roadway sections whereby they are heavily trafficked, priorities should be set forth with respect to the pedestrian safety.

Part III

CBD Bus Terminal Plan

PART III : CBD BUS TERMINAL PLAN

1.0 INTRODUCTION

1.1 Scope of the Study

Existing transport terminal facilities in the CBD of George Town consist of Jetty Bus Terminal for urban buses, Prangin Bus Terminal for regional buses, Komtar Interchange where transfers from urban buses to regional buses or vice versa are facilitated and the Ferry Terminal which provides the linkage with Butterworth (See Figure 1.1.1). In view of the impending construction of the Coastal Road, Prangin Bus Terminal must be relocated elsewhere to make way for the road construction.

The relocation of Prangin Bus Terminal i.e. the selection of a new site has been examined in this Study.

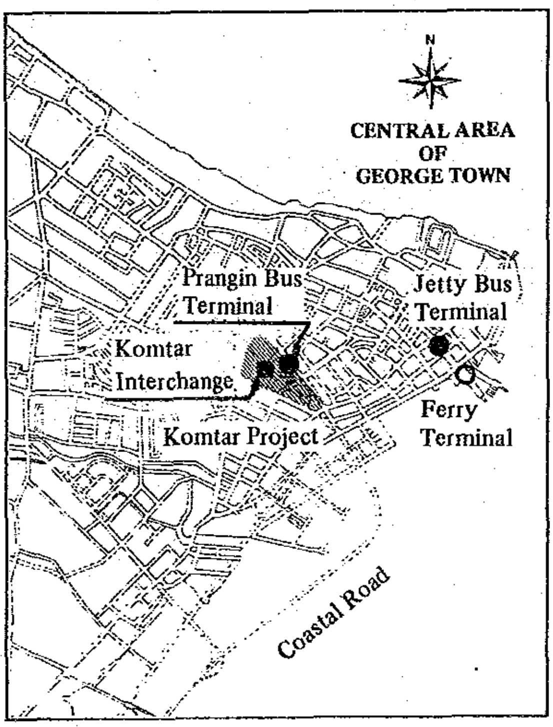


Figure 1.1.1 : Location of Transport Facilities in the Central Area of George Town, 1986

2.0 EXAMINATION AND EVALUATION OF TERMINAL FUNCTION AND LOCATION

2.1 Appraisal of the Present Bus Terminal Locations

The present bus operation pattern, allows transfers from urban buses to regional buses or vice versa at the Komtar Interchange. Figure 2.1.1 illustrates the existing bus operation pattern.

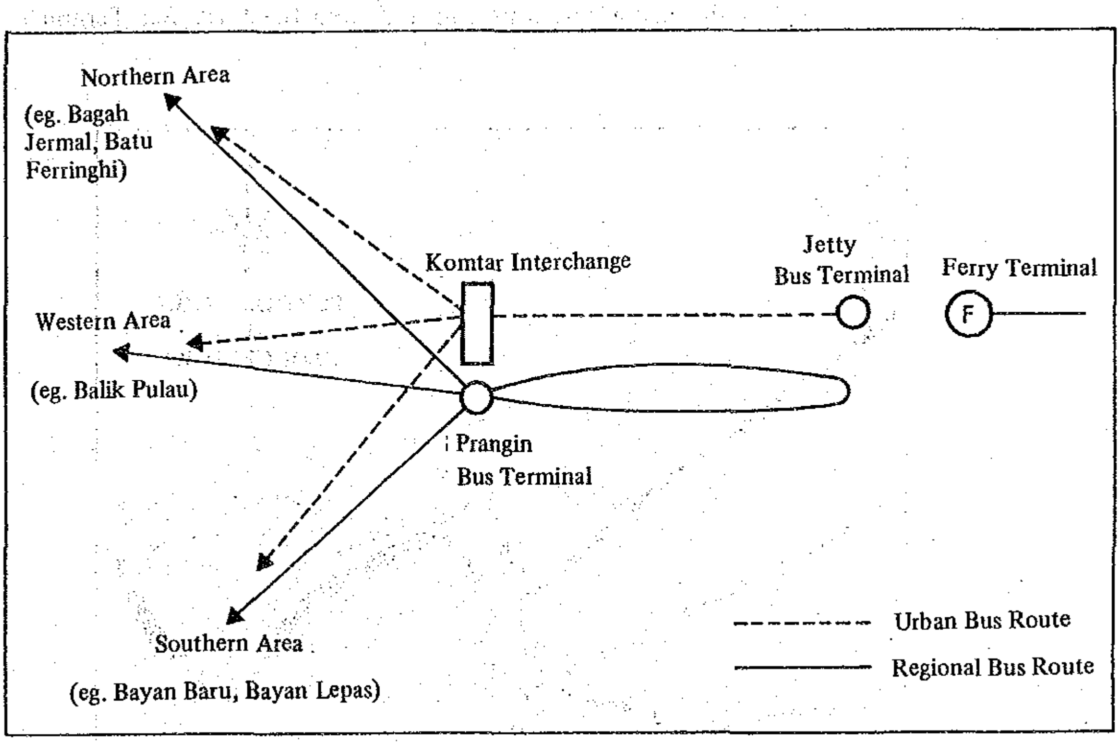


Figure 2.1.1 : Existing Bus Operation Pattern

Based on this existing bus operation pattern the present bus terminal locations are evaluated as below.

A. Merits of Present Bus Terminal Locations

Present bus terminal locations have the following merits:

(1) As Prangin Bus Terminal is located near to Komtar Interchange, they facilitate transfers from urban buses to regional buses or vice versa.

(2) Jetty Bus Terminal being located near to the Ferry Terminal facilitates those who use ferry and urban bus services.

(3) Prangin Bus Terminal is located in the urban core where various urban activities attract bus users. Thus, it is well-situated for the convenience of bus passengers.

B. **Demerits of Present Bus Terminal Locations**

Demerits of the present bus terminal locations are:

(1) Urban buses from or to the Jetty Bus Terminal travel along Chulia Street to Komtar Interchange. It is observed that there are too many buses with frequency of about 1,700 trips per day travel along Chulia Street. Figure 2.1.2 depicts the major bus routes to and from the Jetty Bus Terminal.

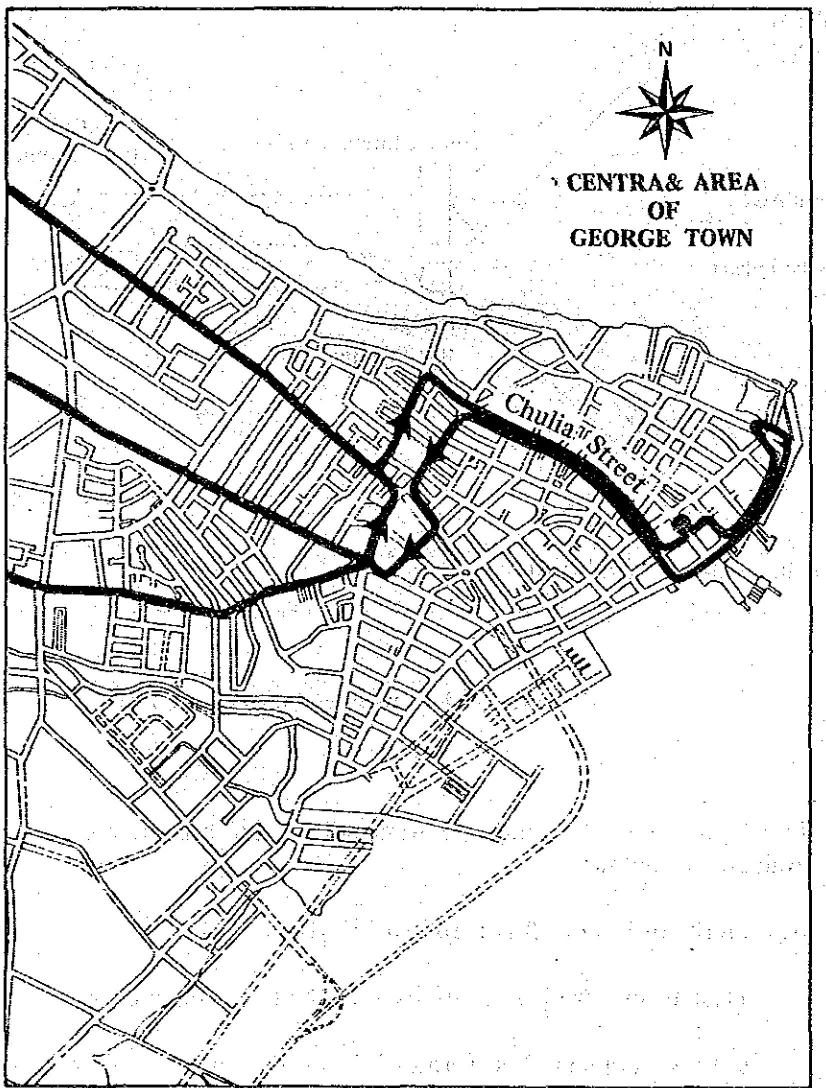


Figure 2.1.2 : Major Bus Route

(2) The frequency of regional bus trips at the Ferry Terminal is only 23% of the total regional bus trips serving the Central Area. Buses (Yellow Buses) serving the southern part of the island for example, do not pass by the Ferry Terminal. Most of the regional buses operate from Prangin Bus Terminal. Table 2.1.1 shows the percentage of regional buses serving the Ferry Terminal.

Table 2.1.1 : Percentage of Regional Bus Serving the Ferry Terminal

Bus Company	Regional Bus Trip No.			Coverage Area
	Central Area (A)	Ferry Terminal (B)	% (B)/(A)	
Hin Bus	480	66	14	Northern Part
Sri Negara	222	222	100	Western Part
Lim Seng Seng	598	150	25	Western Part
Yellow Bus	32	32	100	Western Part
	734	0	0	Southern Part
Total	2066	470	23	

2.2 Candidate Sites for New Bus Terminal

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

A. Existing Bus Transport Facilities

Table 2.2.1 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 every day.

Based on this capacity, the 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 2.2.1 : Utilization Level of Bus Transport Facilities in the CBD of George Town, 1987

Bus Transport Facility	No. of Routes	No. of Trips (Arrival & Departure)	Daily Passenger Volume	No. of Berths	Existing Capacity 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.

B. Pattern of Existing Bus Operation

As Prangin Bus Terminal is located near to Komtar Bus Interchange, it is very convenient for bus transfers. Urban bus 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 generated. These are shown as alternatives in Figure 2.2.1.

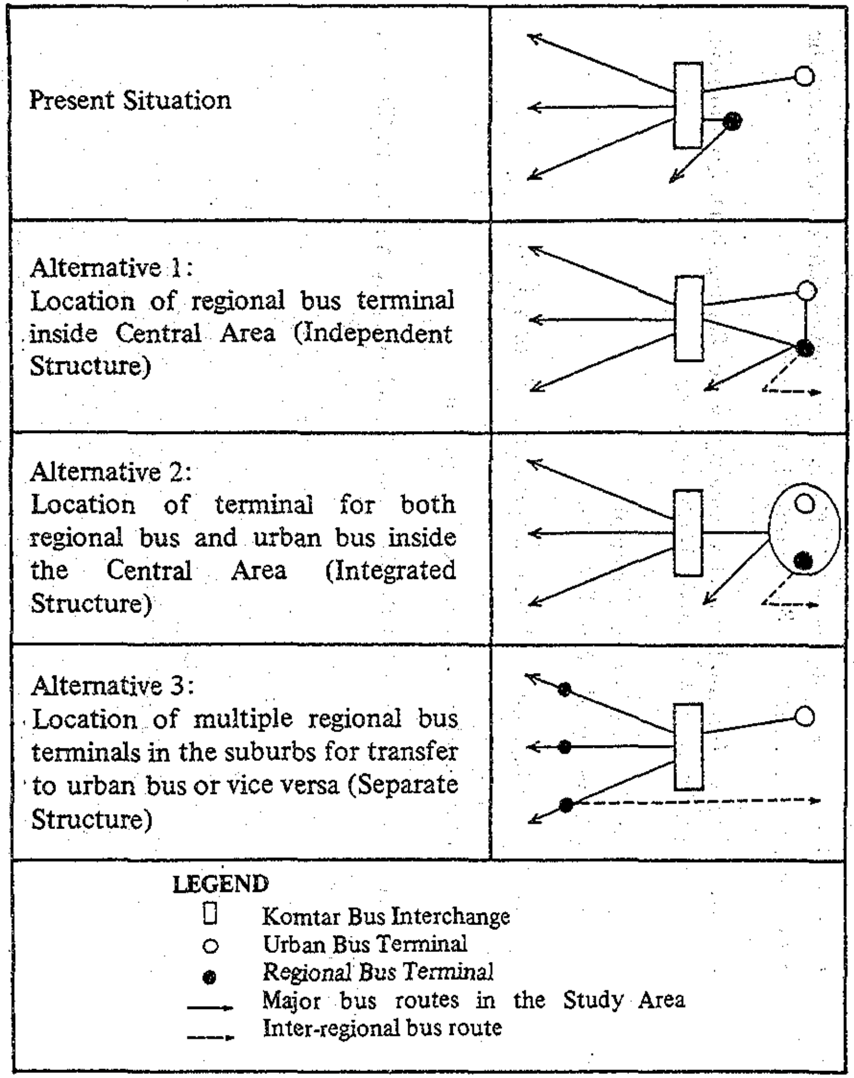


Figure 2.2.1 : Alternative Plans for Bus Operation Pattern

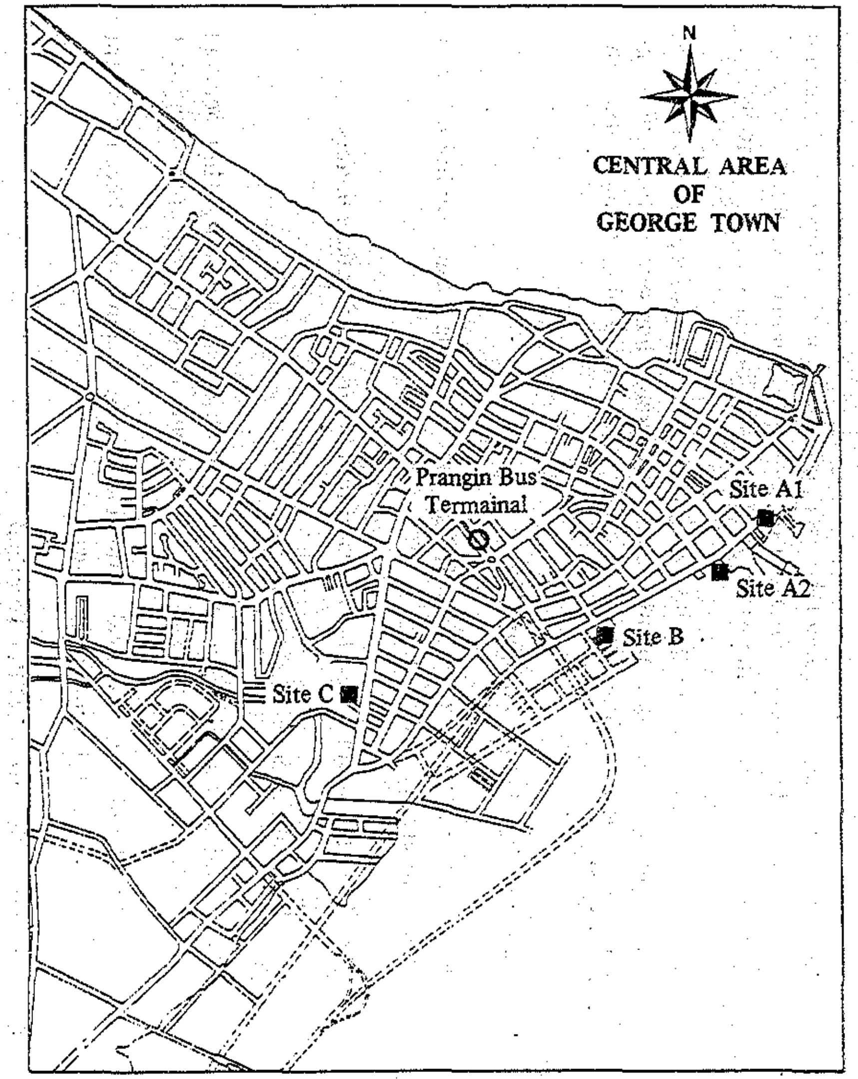


Figure 2.2.2 : Candidate Sites for Relocation of Prangin Bus Terminal

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

Moreover, a bus terminal should be used by as many passengers as possible 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.

C. Basic Conditions for Candidate Site

Based on the preceding discussions, the following basic conditions for a candidate site are obtained:

(1) The site should have a land area of more than 5,000 square meters

(2) It should be located in the Central Area.

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

(4) The Land must be made available within a short time because of the urgency to relocate Prangin Bus Terminal.

D. Candidate Sites for CBD Bus Terminal

The following four (4) sites shown in Figure 2.2.2 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. Some reclamation work may also be required.

A1. North-east of Ferry Terminal
A2. South-west of Ferry Terminal

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

C. On MPPP's land earmark for redevelopment

However, for convenience of the following discussion, Site A refers to Sites A1 and/or A2.

2.3 Screening of Candidate Site

A. 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:

(1) Serving as the arrival and departure point for regional and inter-regional bus passengers,

(2) Serving as the point for transfer to other buses or other transport modes, and

(3) Serving as one of the elements in determining the urban structure.

A bus terminal is a facility for bus users, it is therefore desirable that as many people will utilize it in the process, the area around the terminal be transformed into a new urban activity core in the city.

Another possible function of a bus terminal is a place for readjusting the bus schedules, i.e., that of a bus depot.

However, the characteristics of a bus terminal for passengers is quite different from a bus depot. 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 the examination of the relocation of Prangin Bus Terminal, the site for a CBD Bus terminal will be determined by its capability to fulfill the abovementioned three (3) basic functions of a terminal from the standpoint of bus users.

B. *Evaluation from the Present Bus Users' Viewpoint*

The users movement of the existing Prangin Bus Terminal can be categorized into the following three patterns:

(1) From KOMTAR Area to Prangin Bus Terminal

This is the movement pattern of those passengers coming from the KOMTAR Area after work or shopping. Most of them can walk from their place of origin to the bus terminal.

(2) From Ferry Terminal Area to Prangin Bus Terminal

This is the movement pattern of those passengers who take an urban bus from the Ferry Terminal area and transfer at Prangin Bus Terminal.

(3) From Other Areas to Prangin Bus Terminal

This is the movement pattern of those passengers who come from areas other than the KOMTAR area or Ferry Terminal area using either urban bus or regional bus and transfer at the Prangin Bus Terminal.

The candidate sites are then evaluated on the abovementioned passenger movement patterns. The evaluation is summarised in Table 2.3.1 and Figure 2.3.1.

Table 2.3.1 : Evaluation of Sites from Standpoint of Present Prangin Bus Terminal Users

To/From	SITE A	SITE B	SITE C
KOMTAR Area	╳	△ (distance = 700m)	△ (distance = 800m)
Ferry Terminal Area	◎	○ (distance = 700m)	╳

Notes :

◎ Better than present situation

○ Slightly better than present situation

△ Slightly worse than present situation

╳ Worse than present situation

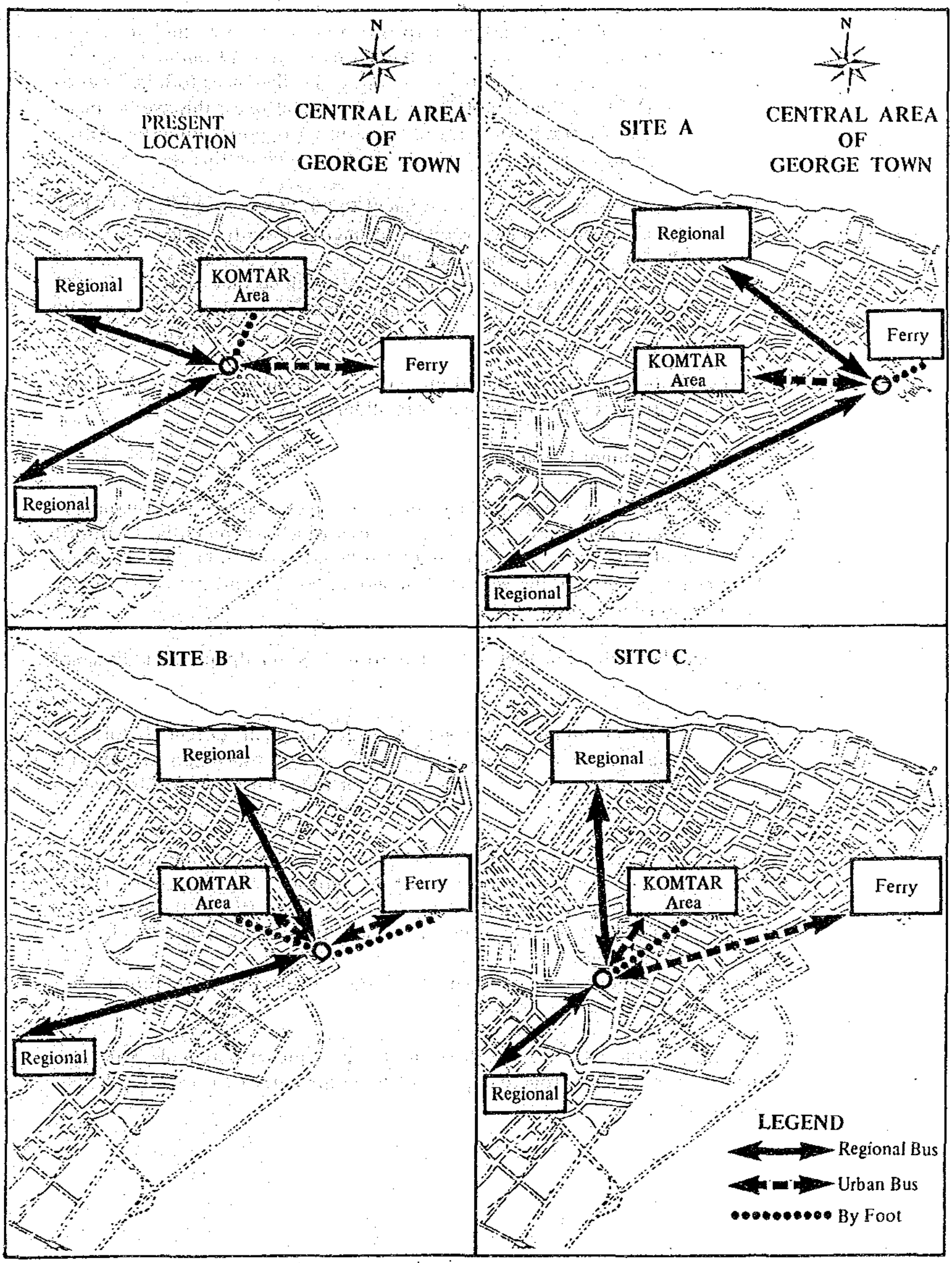


Figure 2.3.1 : Access/Egress Modes to Bus Terminal at each Candidate Site

Site A: Site A is very convenient to bus users from/to around the Ferry Terminal area. However, to the bus users around Komtar area, a bus terminal located here is too far away and they need to take a bus to reach it. If their destinations are regional ones, this would mean having to travel an extra distance in an opposite direction before catching on a bus from there to their intended destinations.

Site B: Site B is also not very convenient to bus users around the KOMTAR area, but the distance is only 700 metres from the present location. With proper provision of pedestrian path and the operation of circulation bus the terminal on this site will become more convenient. Moreover, to the bus users coming from around Ferry Terminal, Site B is more convenient to use compared to the existing situation.

Site C: Site C being too far from both the Komtar area and the Ferry Terminal is too inconvenient to all bus users.

C. **Future Development Prospects**

The construction of a bus terminal can be an impetus to urban development. Thus, it is desirable to construct it in an area which has potential for future development and where new bus users can be attracted from its surrounding development area. At the very least, it should not be constructed in an area where terminal users may decrease.

The candidate sites are then evaluated from this standpoint and discussed below.

Site A: The surrounding area has low development potential for new business and commercial activities. Conservation of existing environment is the major theme for the landuse in the surrounding area.

Site B: Depending on the landuse planning of the surrounding area, Site B has strong potential to transform into a new urban core. Future development around KOMTAR will make the distance between KOMTAR as a city centre point and the bus terminal even closer to each other.

Site C: With urban redevelopment of the surrounding area, Site C may become a new urban core.

Therefore, while Sites B and C have future development potentials, Site A has the disadvantage of having to depend solely on the Ferry users (See Table 2.3.2 for details).

Table 2.3.2 (1) : Evaluation of Alternative Plans for Bus Terminal

Alternatives	Candidate Site	Functionality	Intermodal (inter bus) Transfer	Changes to existing bus routes	Transport Efficiency (Access to high demand area)	Space of Terminal Level considered 10,000 sq. m.	Relationship with other business and problems concerning land acquisition, etc.
Plan 1	A1	Terminal for urban bus, inter-regional bus and tour bus	Most convenient because all buses utilise the same terminal. Also easy to transfer from urban bus to ferry or vice versa	The existing urban bus routes can be maintained because the candidate site is near to the existing Jetty Bus Terminal. Regional bus routes will become longer by about 1.5km. But basically routing remains unchanged.	Near to business area around Beach Street	Construction Cost = M$ 1.0m Land Acquisition = (M$10.8m) Total M$ 1.0m (M$11.8m) ( ) figures inside brackets is amount needed in the case when land acquisition is necessary	May be possible to use existing car park area but needs some land reclamation. Parking facility can be provided by constructing a multi-storey terminal building to replace existing one. Being near the business area, land cost is high and the total project cost would be become a problem if land has to be acquired. However, if PPC could be asked to manage the building, including the parking facility, etc. the land acquisition cost can be removed from the project cost.
Plan 2	A1	Terminal for regional bus, inter-regional bus and tour bus (Urban bus to use existing terminal	Transfer to urban buses become slightly inconvenient. Walking distance between terminals is about 200–300m	Urban bus routes remain unchanged. Regional bus routes as in Plan 1.	As in Plan 1	Construction Cost = M$ 0.6m Land Acquisition = (M$ 7.2m) Total M$ 0.6m (M$ 7.8m) ( ) figures inside brackets is amount needed in the case when land acquisition is necessary	As in Plan 1
Plan 3	A2	Terminal for urban bus, regional bus, inter-regional bus and tour bus	As in Plan 1	Not very different from Plan 1	As in Plan 1	Construction Cost = M$ 1.0m Reclamation = M$ 1.4m Squatter eviction = M$ 0.8m Total M$ 3.2m	Necessary to reclaim new area and to evict existing squatter population
Plan 4	A2	Terminal for regional bus, inter-regional bus and tour bus (Urban bus to use existing terminal)	As in Plan 2	As in Plan 2	As in Plan 1	Construction Cost = M$ 0.7m Reclamation = M$ 1.0m Squatter eviction = M$ 0.5m Total M$ 2.2m	As in Plan 3

Table 2.3.3 (2) : Evaluation of Alternative Plans for Bus Terminal

Alternatives	Candidate Site	Functionality	Intermodal (inter bus) Transfer	Changes to existing bus routes	Transport Efficiency (Access to high demand area)	Space of Terminal Level considered 10,000 sq.m.	Relationship with other business and problems concerning land acquisition, etc.
Plan 5	B	Terminal for regional bus, inter-regional bus and tour bus (Urban bus to use existing terminal)	Transfer from regional bus to urban or vice-versa would take place at Komtar Interchange. Transfer to ferry requires walking about 700m or to take another bus at KOMTAR. No improvement in terms of convenience to ferry users (existing circumstances)	Site is relocated to about 400m to the east of Prangin Bus Terminal. Therefore, existing bus routes remain basically unchanged.	Slightly far from existing high demand area such as KOMTAR and Beach Street. However, with the expansion of the CBD, demand could be expected to increase if the location becomes a statregic point for new urban development.	Construction Cost = M$ 0.7m Land Acquisition = M$ 2.9m Total MM$ 3.6m	Land acquisition is relatively cheaper because the area is newly reclaimed land. The siting of a terminal building here enhances the development of this reclamation area with suitable landuses.
Plan 6	C	Terminal for regional bus, inter-regional bus and tour bus (Urban bus to use existing terminal)	Transfer to urban buses or vice versa would take place at Komtar Interchange. Transfer to ferry would be by bus via KOMTAR.	Because the sites is rather to the south of Komtar Interchange, bus routes on Juletong Road would have to make long detours to enter KOMTAR Interchange.	A problem on transport efficiency because the site is far from the high demand area in the CBD such as KOMTAR and Beach Street.	Construction Cost = M$ 0.7m Land Acquisition = M$ 2.2m Total M$ 2.9m	Land acquisition is relatively cheaper because the area is newly reclaimed land. The development of the reclamation land with suitable landuses would require some effort.

D. Conclusion

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

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

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

(3) In the future, it will be possible to expand the facilities on Site B to accommodate the capacity of the existing Jetty Bus Terminal.

(4) 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.

However, 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 2.3.2 shows the proposed bus operation pattern in the Central Area when the CBD Bus Terminal is located on Site B.

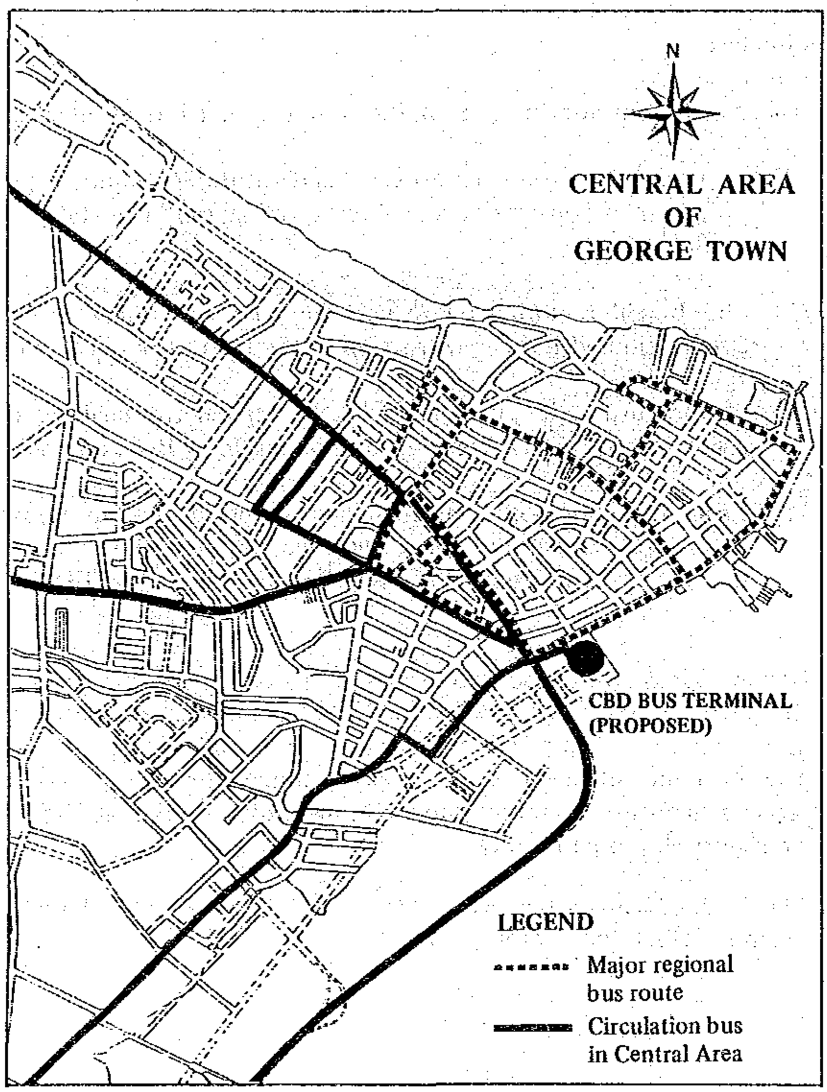


Figure 2.3.2 : Concept of Reorganized Bus Route Network in Central Area