THE COMPUTERIZED AREA TRAFFIC CONTROL SYSTEM IN PENANG, MALAYSIA

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Abstract: This paper will describe the "computerized area traffic control system" planned and implemented in Penang, Malaysia in cooperation with the Japanese and the Malaysian governments. It will also introduce the Area Traffic Control system (ATC system) and the plans for the improvement of intersections.

1. INTRODUCTION

In response to the request made by the Malaysian government to the Japanese government regarding urban traffic planning in the Johor Bahru and the Penang metropolitan areas, the Japan International Cooperation Agency (JICA) undertook feasibility studies of both cities. The study of the Penang metropolitan area was conducted to consider long- and short-term plans for solving present and possible future traffic problems as part of the Penang Metropolitan Area Transport Master Plan.

2. OUTLINE OF THE PENANG METROPOLITAN AREA

Located in the northeast of Penang Island, Penang is the capital of Penang Province. Penang was developed in the 18th century by the British East India Company as a trade base, and grew as a free port. Penang Island covers an area of 295 square kilometers and has a population of some 500,000. Penang City (George Town) is the largest urban area on Penang Island and has a population of approximately 260,000. (See Figure 1)
George Town's urban development was planned by the British during the colonial era. The city's commercial district is located behind the port area, and residential housing is situated on its periphery. Higher class residential areas are located in the suburbs.
The road network in the commercial district has been laid in a grid pattern, while the road network in the suburbs is radial.The roads and roadside trees in the outskirts of the city are harmonized beautifully, making the suburbs particularly attractive.

Vehicle (four-wheeled and over) ownership stands at 156 vehicles per 1,000 people, and motorcycle ownership (two-wheeled) is particularly high at 217 per 1,000 people. Trishaws—three-wheeled vehicles propelled by the driver pedaling as on a tricycle—are also used by tourists and inhabitants of the city; there are approximately 1,900 of these in George Town. Trishaws are, however, declining in numbers; this is the result of the authorities deciding not to issue new Trishaw permits as part of an effort to stop these vehicles holding up traffic.

Penang lost its predominant position after the end of the second world war owing to the rise in prosperity of Singapore. The 1970's saw an increase in unemployment and an out-flow of the young working population as a result of Penang's loss of free port status. The provincial government initiated the three policies of attracting industry to the area, promotion of tourism, and urban development to activate the economy and to reduce unemployment.

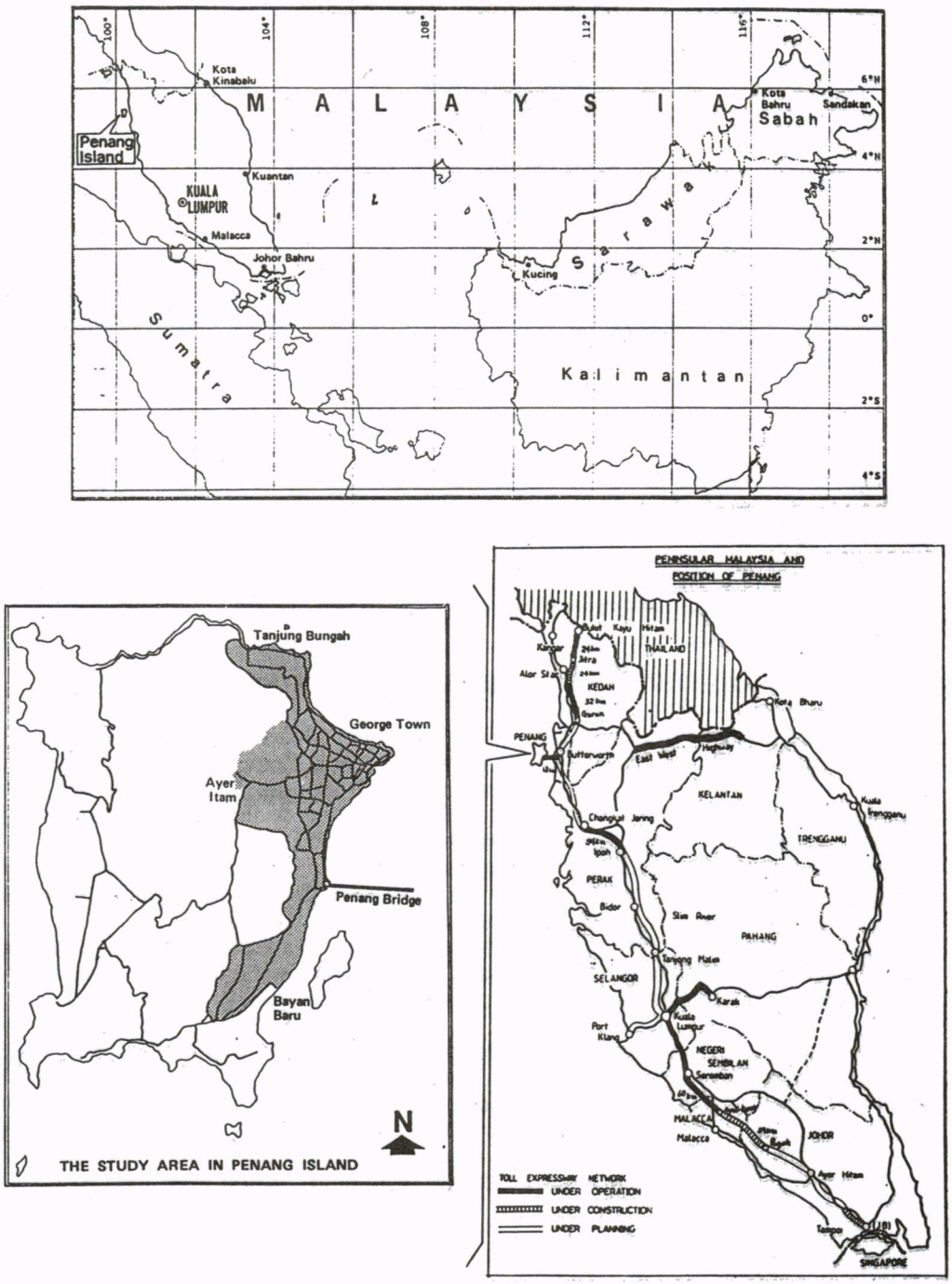


Figure 1 Location Map

3. PENANG METROPOLITAN AREA TRANSPORT MASTERPLAN

3.1 Survey of Present Conditions

Recent developments in the Penang metropolitan area—most notably urbanization of the population, the attraction of industry to the area, greater vehicle ownership, and the improvement in living standards—have led to problems such as greater traffic congestion and more frequent traffic accidents. Between 1979 and 1982, the Japanese government (JICA) conducted a comprehensive study into possible solutions to these urban problems.

A detailed survey, including a vehicle OD survey, was made of various aspects of traffic in the Penang metropolitan area, Butterworth on the mainland, and other areas. The survey noted the following problem areas:

a. Complex mixed traffic flow of automobiles, motorcycles, and trishaws
b. Inefficient road use
c. Traffic signals are too small and have poor visibility
d. Inadequate road signs and road markings
e. Inadequate pedestrian facilities
f. Inadequate roads for volume of traffic inflow from Penang Bridge (completed 1985)

Figures 2 and 3 on the next page show the George Town road hierarchy and the degree of congestion on major roads, and the photographs on the following page show road conditions.

3.2 Proposal of Penang Metropolitan Area Transport Masterplan

The following long-term and short-term plans were proposed to solve these problems—these were based on the concepts of landuse and development shown in Figures 4 and 5.

Long-term plans:

1. Introduction of one-way traffic systems on the major roads in the city center
2. Outer ring highway plan

Short-term plans:

1. Area Traffic Control system plan (ATC system)
2. Intersection improvement plan
3. Parking regulation and control plan
4. Bus network reorganization plan

Figure 6 shows the proposed road network in Penang.

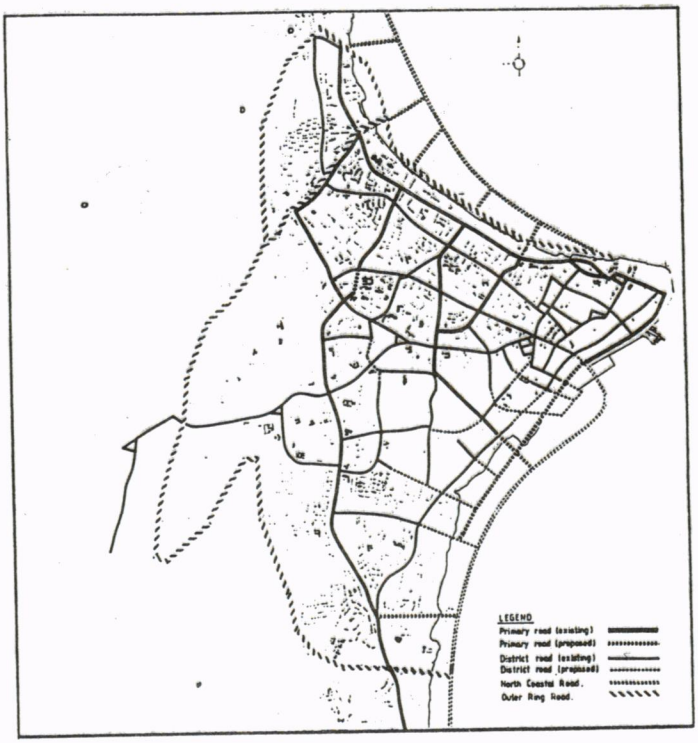


Figure 2 Road Hierarchy

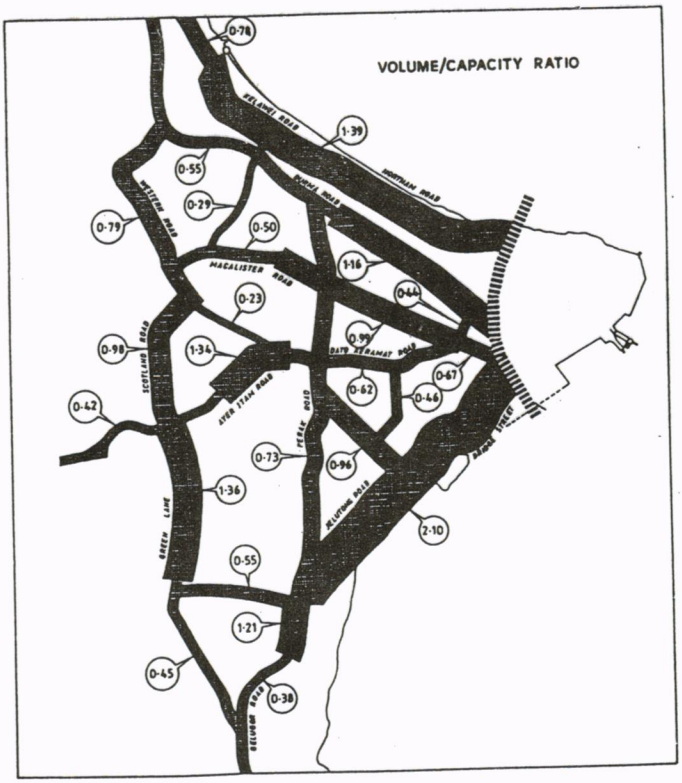
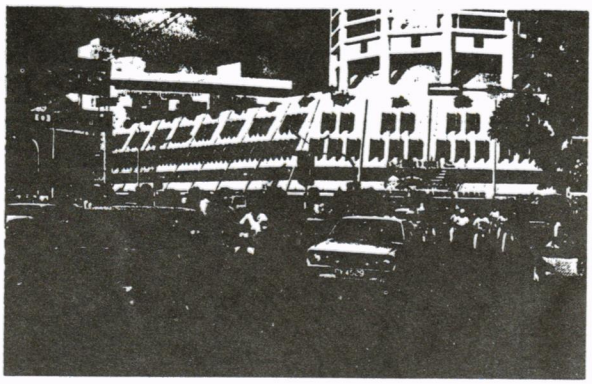
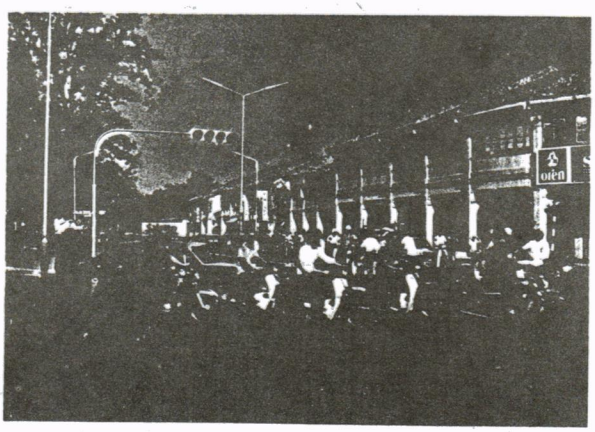
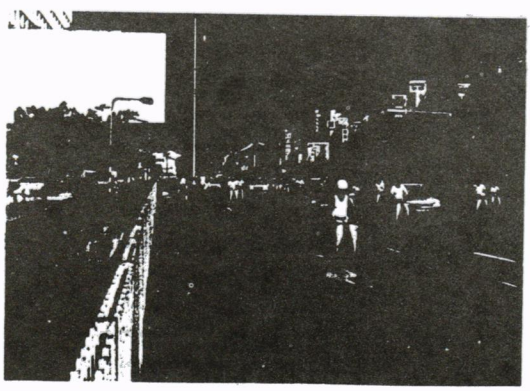


Figure 3 Degree of Congestion on Major Roads







1 2 3 6 4 5

1. *Traffic condition along Jelutong Road during the evening peak.*
2. *The second highest delay time has been recorded at Magazine Circus.*
3. *Traffic condition along Northam Road during the morning peak.*
4. *The highest delay time was recorded at the Perak Road/Dato Keramat Road Intersection.*
5. *Traffic Condition around KOMTAR along Magazine Road.*
6. *Absent or faded lane markings encourages careless or undisciplined driving habits.*

Photographs Road Conditions

Landuse and Development Plan for Penang Metropolitan Area
(Proposed by JICA Team, 1980)

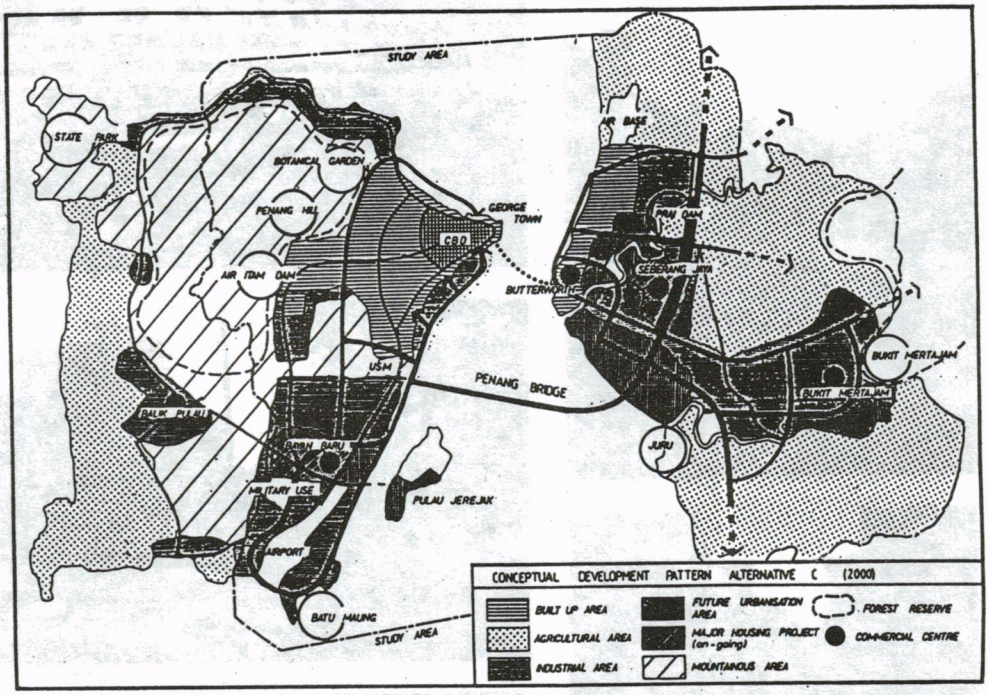


Figure 4 Landuse and Development Plan

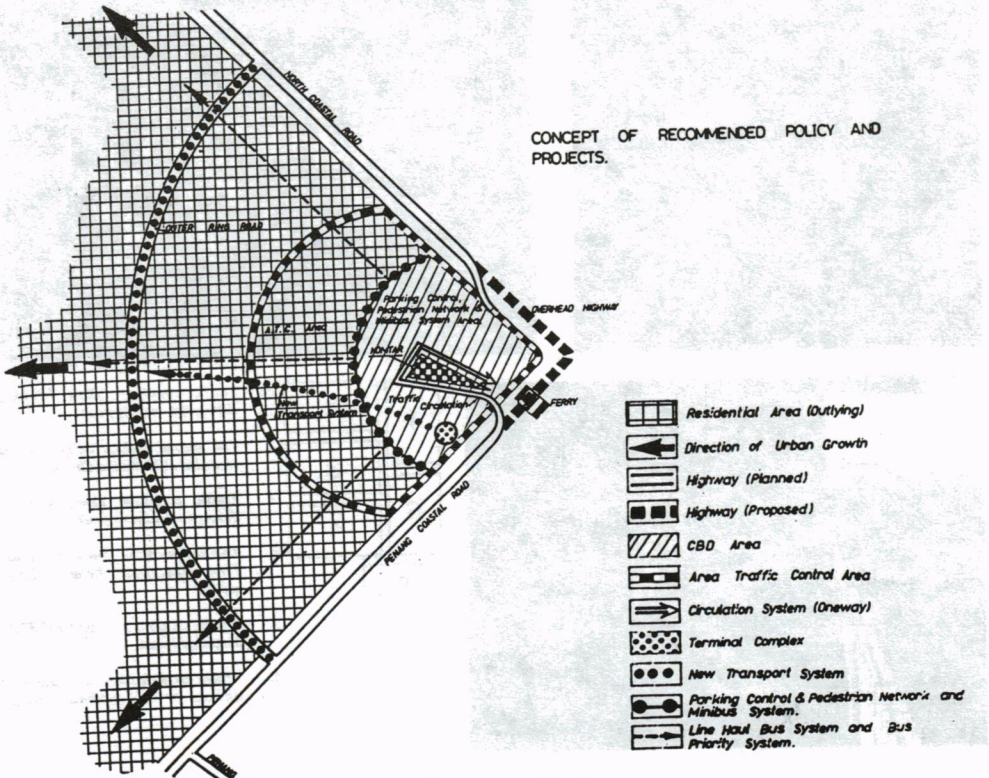


Figure 5 Concept of Projects

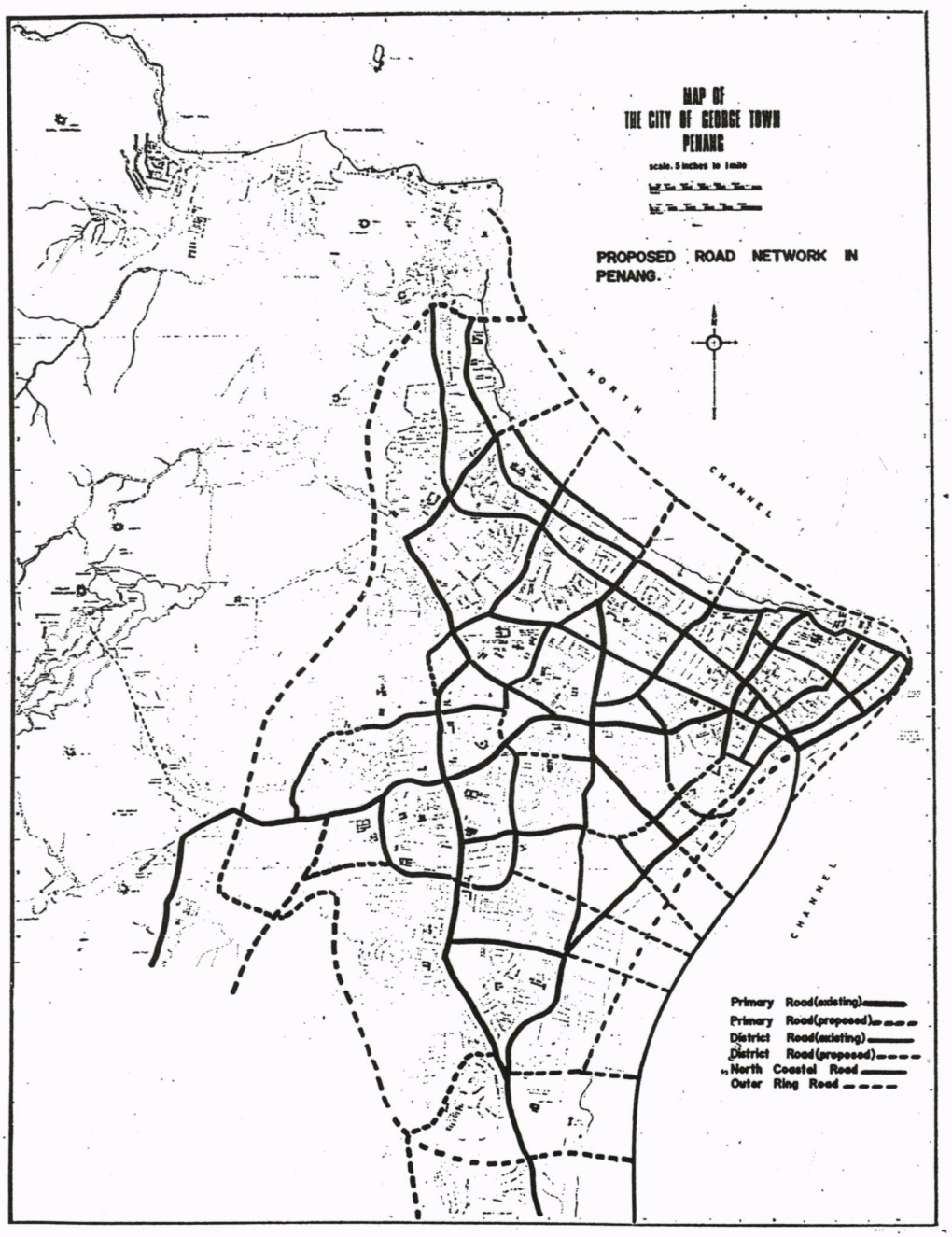


Figure 6 Proposed Road Network in Penang

4. INTRODUCTION OF THE ATC SYSTEM, AND TRAFFIC CONTROL CENTER

4.1 Realization of Short-term Plans

Long-term dispatch of experts was requested for the realization of the short-term plans. Two JICA experts were dispatched accordingly from 1981 to 1984; the author of this paper was dispatched to Penang between 1985 to 1988 to continue their work.

These experts prepared implementation plans for the introduction of the ATC system, intersection improvement, and the installation of traffic signal devices.

It was decided by the Penang City Council to introduce the ATC system in George Town in 1985, after completion of Penang Bridge and the KOMTAR urban redevelopment project (phase one). This was the second such project in Malaysia; the system had previously been introduced in the capital, Kuala Lumpur.

In 1984, following this decision, the Malaysian government requested the Japanese government to provide the computer control equipment necessary for the system, detailed plans of the system, and plans for the future.

4.2 Donation of Equipment by JICA

Based on the request made by the Malaysian government, JICA decided to donate the Traffic Control Center computer system as its contribution for fiscal 1985. Following further development investigations, JICA also decided to formulate plans for ATC system expansion and comprehensive traffic control. The Penang project was called the "Penang ATC Project."

The computer system and terminal equipment were supplied in March 1986. The total value of the computer system was M$800,000 (¥60,000,000 at 1986 exchange rates).

- Traffic signal controller
  Central processing unit (CPU), MODEM, traffic condition display map, closed circuit TV (CCTV), typewriter, transformer, signal control software, etc
- Centrally controlled signal equipment and detector units
  Microcomputer, LSI controller, vehicle detector units (loop coil type), etc

5. ATC CENTER INSTALLATION, INTERSECTION IMPROVEMENT

5.1 ATC Center Installation Work

The traffic signals and closed circuit television cameras are controlled from the ATC Center.

5.1.1 ATC Center System

According to the original plan, 37 intersections were to be covered by the ATC system.
A deterioration in government finances, however, meant that funds were insufficient to meet the cost of the initial plan. A five-year, three-stage plan was therefore adopted instead, with only 16 intersections being covered by stage I. (Figures 7 and 8). Of this number, existing signals were replaced by new controllers at 12 intersections, and new sets of traffic signals were installed at the remaining 4.

Figure 9 shows the ATC Center system design, and Figure 10 shows the ATC Center layout.

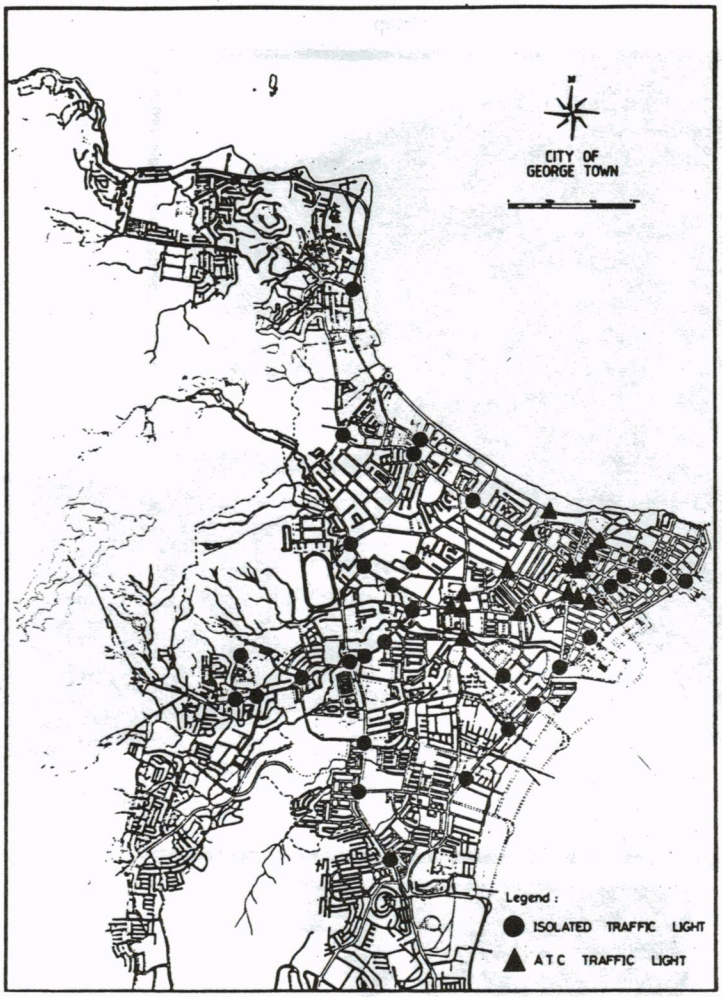


Figure 7 Traffic Light Installation in George Town

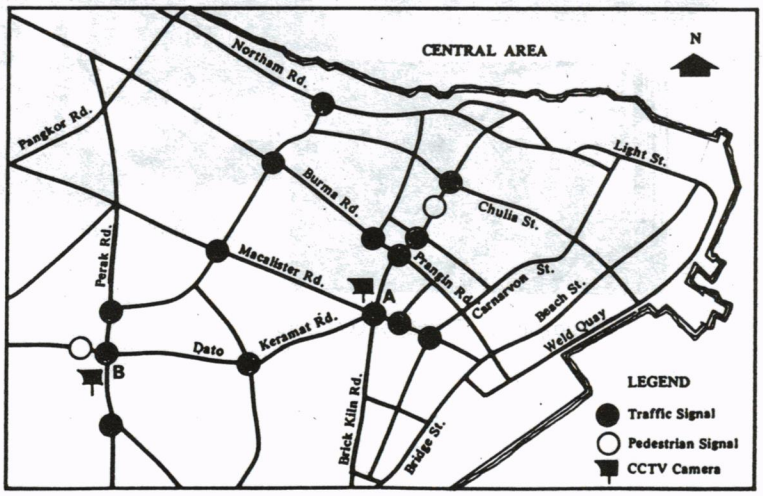
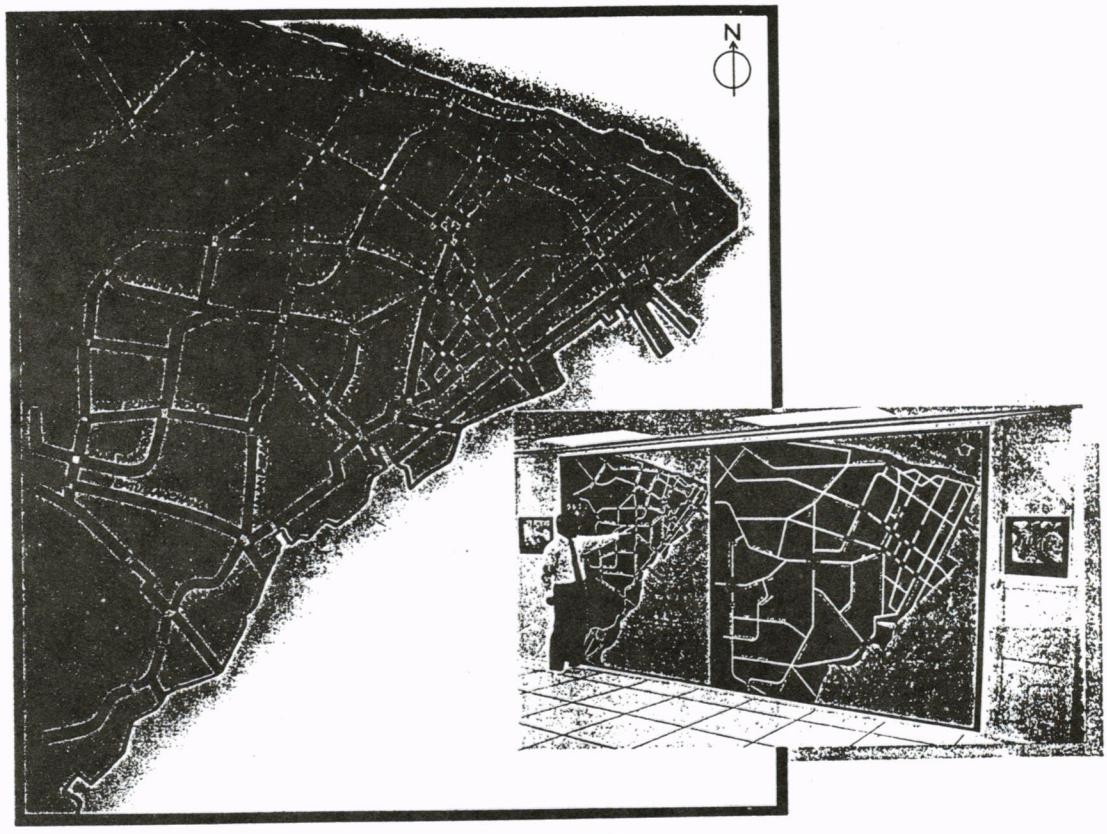
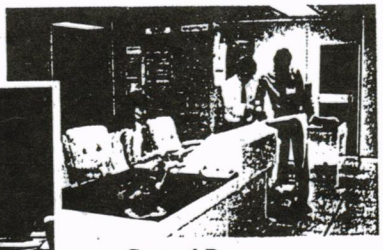


Figure 8 Signal Locations in Stage I of the ATC System

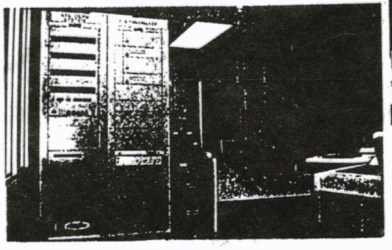
Wall Map



Area Traffic Control Center



Control Room



Main Computer

Photographs Penang ATC Center

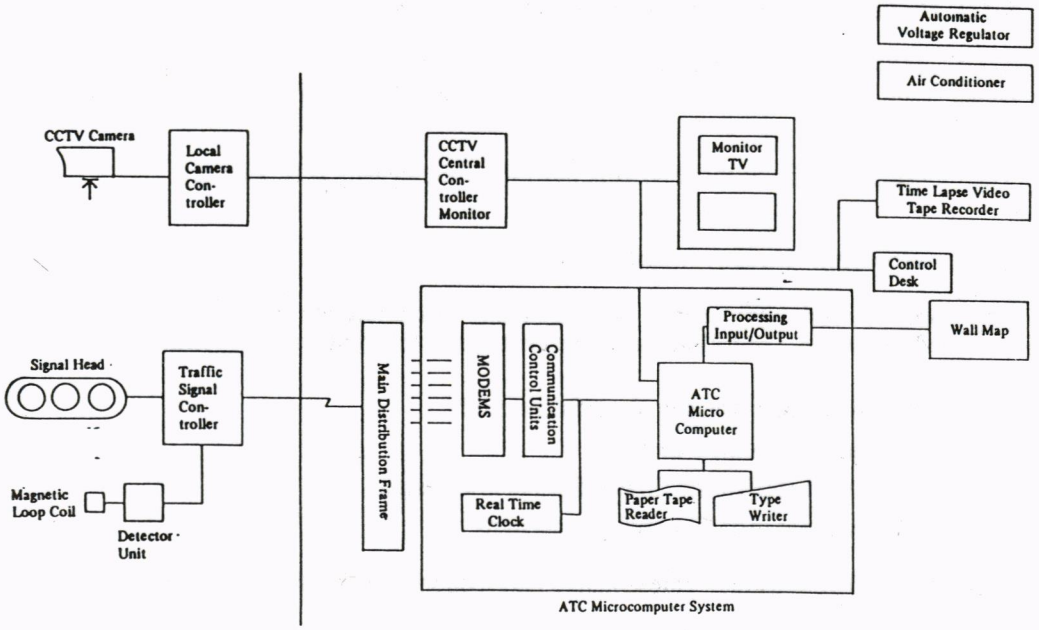


Figure 9 Stage I System Design

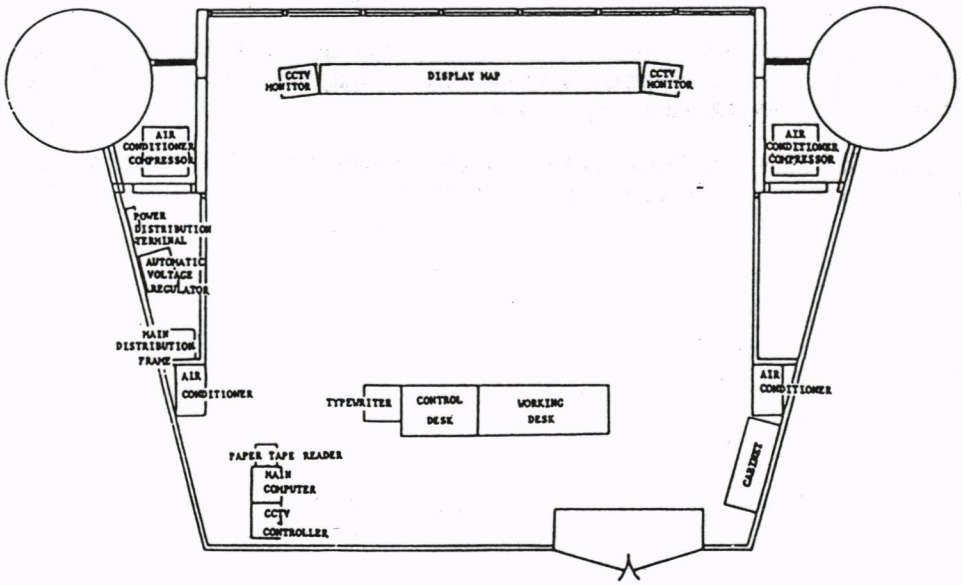


Figure 10 Central Control Room Layout in Stage I

5.1.2 Closed Circuit Television System (CCTV)

The CCTV system consists of two cameras, two monitors and a control desk. The CCTV cameras are installed at (A) level 64, KOMTAR tower and (B) intersection as shown in Figure 8.

The four photographs on the following page show the Penang ATC Center.

5.2 Intersection Improvement Works

Improvement work was carried out based on 16 intersection plans,of which 10 were modified by author. The following are the contents of the improvement work:

- Installation of traffic signals and controllers
- Installation of vehicle detectors
- Improvement of traffic flow and geometric design
- Improvement in road markings and signs

Figures 11 and 12 illustrate representative intersections which have been improved.

The construction periods for ATC system installation work and improvement work were as follows:

• ATC system central equipment installation	4 months
• ATC system terminal equipment installation	6 months
• Related intersection improvement (16 intersections)	18 months

Test operations began in April 1987, after improvement work had been completed. Following the four months required for readjusting the computer software, the Penang ATC Center was officially opened in August 1988.

The Municipal Council of Penang Island paid for the installation of the central and terminal equipment, and the work on intersection improvement.

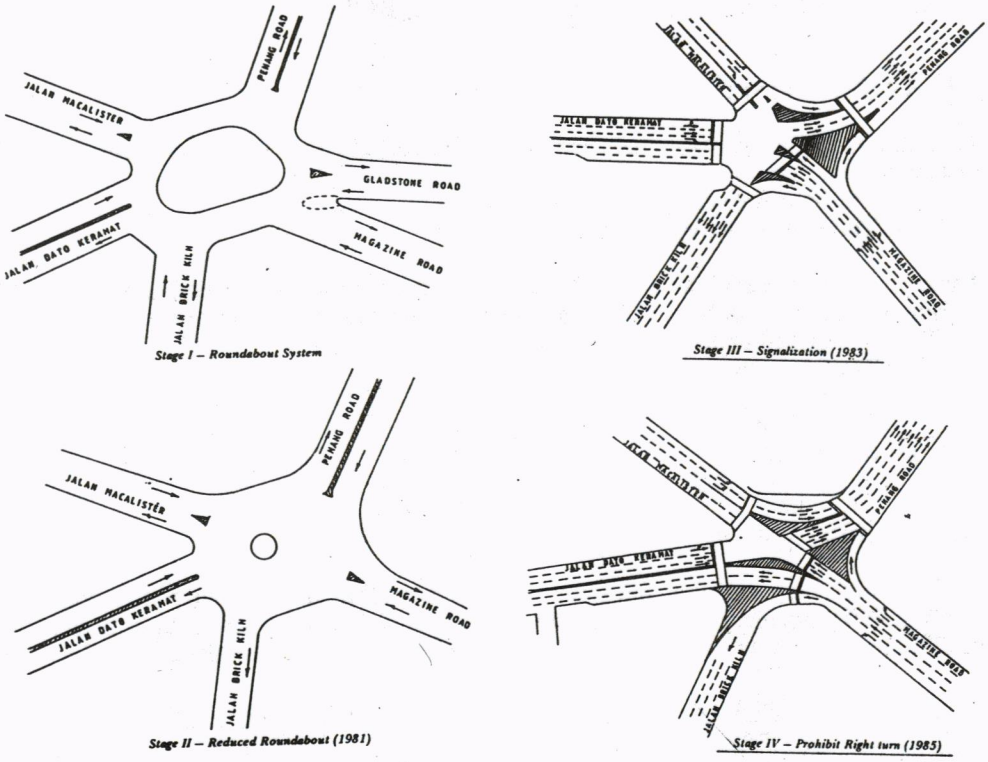


Figure 11 Improvements at Magazine Intersection

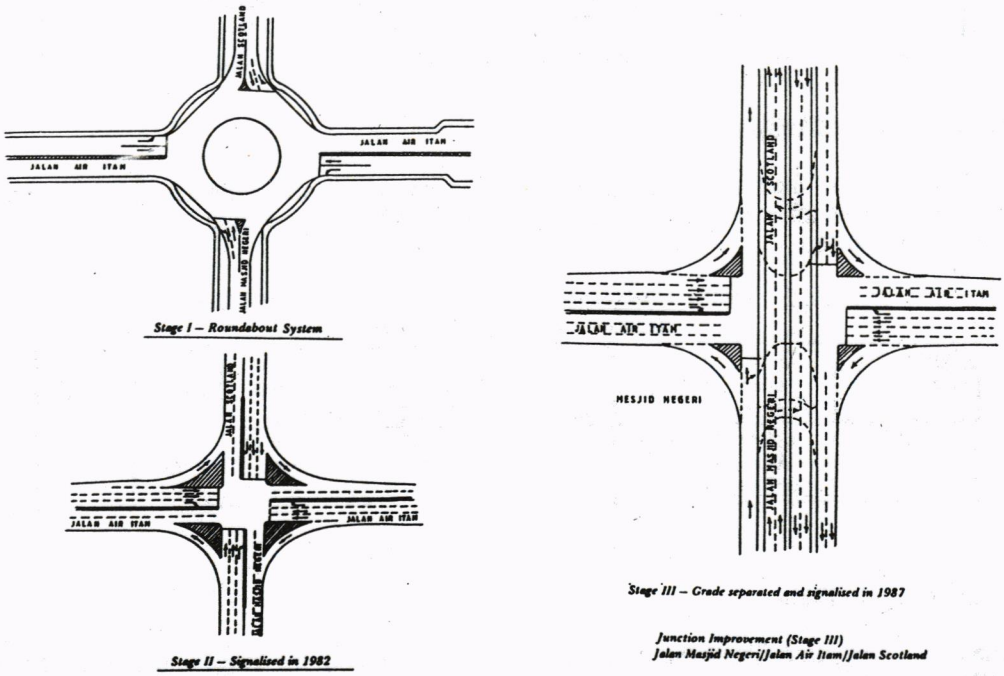


Figure 12 Junction Improvements

6. EVALUATION OF PENANG ATC PROJECT

6.1. Traffic Survey

The relevant traffic surveys conducted with a "before and after study" to evaluate the ATC System were:

(1) Traffic count survey at intersections
(2) Travel time survey on main routes

These surveys were used as a basis for comparisons for the "before and after study." This section discusses the traffic conditions before and after the operation of the ATC system in 1987. It is described under the following items:

(1) Traffic volume
(2) Traffic composition
(3) Travel time
(4) Delay time

6.1.1 Traffic Volume

Table 1. shows the morning and evening peaks as well as the 12-hour traffic volumes (in terms of PCU) obtained from the "before and after study". On the whole, there is an increase of 2.8% in the 12-hour traffic volume for the intersections covered under the ATC System.

Table 1 Traffic Volume 'Before' and 'After' Installation

Intersection			Traffic Volume		
No. Name	'Before'/ 'After' Installation		Morning Peak (8am-9am)	Evening Peak (5pm-6pm)	12 Hours (7am-7pm)
Total	Before	PCU	46301	61220	621954
	After	PCU	48140	63678	639602
	Difference	PCU	1839	2458	17648
	Difference	%	4.0	4.0	2.8

6.1.2 Traffic Composition

Table 2 illustrates the traffic composition of 12-hour vehicle traffic volumes obtained from the "before and after study." On the whole, the traffic composition does not exhibit significant changes

Table 2 Traffic Composition of 12-hour Vehicle Traffic Volume 'Before' and 'After Installation

Intersection No. Name	'Before'/ 'After' Installation	Motor-cycle	Car, Taxi, Van & Pick-up	Medium Lorry & Mini Bus	Heavy Lorry & Bus	Others	Total
Total	Before	48.7	40.6	1.7	1.6	7.4	100
	After	50.3	39.1	1.7	1.6	7.4	100
	Difference	1.6	-1.6	0.1	0.1	-0.1	

6.1.3 Travel Time

One of the ways to evaluate the ATC System is by comparing the travel time along certain routes obtained form the "before and after study." Generally, the morning peak travel time is reduced by 15%, afternoon peak by 12% and evening peak by as much as 22%. Thus, the

travel time along all the routes considered is reduced by about 16%. Figure 13 illustrates the difference in "before and after study" travel time for morning, afternoon and evening peaks as well as for all peak periods.

However, this comparison of the "before and after study" travel time is based on different data, i.e. different traffic volume. It must be noted that the after study traffic volume is higher than that of the before study. Thus, if the same level of traffic volume is used for the after study, then the travel time will be shorter than it was surveyed.

Table 3 Travel Time and Travel Speed 'Before' and 'After' Installation

Route No.	Route Name	Peak Period	Distance (km)	Travel Time 'Before' Installation (second)	Travel Time 'After' Installation (second)	Travel Time Difference (second)	Travel Time Difference %	Travel Speed 'Before' Installation (km/h)	Travel Speed 'After' Installation (km/h)	Travel Speed Difference (km/h)
	SUB-TOTAL	Morning	27.93	4117.7	3521.4	-596.3	-14.5	24.4	28.6	4.1
		Afternoon	27.93	4558.1	4023.2	-534.9	-11.7	22.1	25.0	2.9
		Evening	27.93	5080.3	3974.9	-1085.5	-21.5	19.9	25.3	5.4
	TOTAL		83.79	13736.1	11519.5	-2216.6	-16.1	22.0	26.2	4.2

* The time periods for the survey are:
Morning 7:00 to 10:00 am
Noon 12:00 to 2:00 pm
Evening 5:00 to 8:00 pm

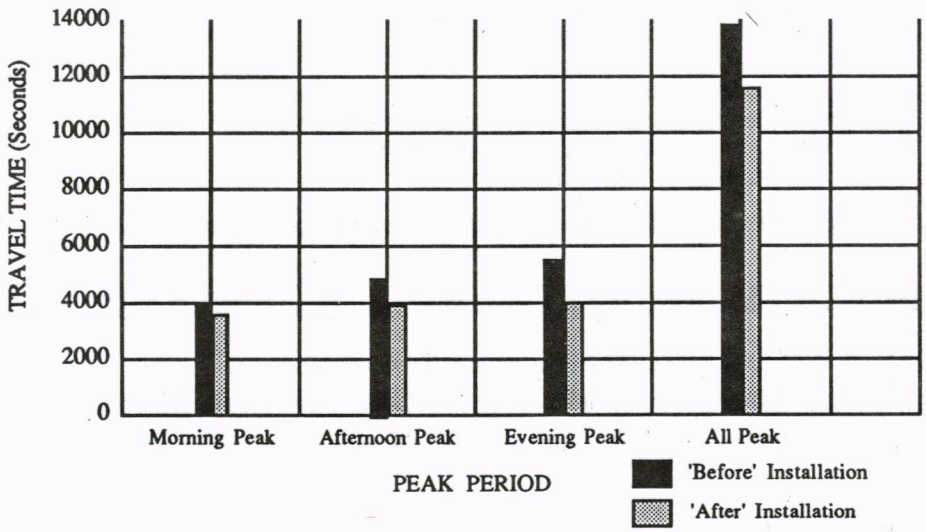


Figure 13 Difference in 'Before' and 'After' Installation Travel Time

6.1.4 Delay Time

Of the 16 intersections that were controlled by the ATC System, eight exhibited reductions in delay time. (Table 4.) The main reasons for the reductions were: the establishment of right turning lanes, building of pedestrian crossings and improvements gained from the introduction of traffic lights, such as a changes in road priority and channelization.

At intersections where the delay increased, it is thought that the replacement of roundabouts with traffic lights limited the traffic flow of the priority roads.

Table 4 Delay Time 'Before' and 'After' Installation

Intersection		Delay Time (Hours)		Comments
No. Name	'Before'/ 'After' Installation	Morning Peak, Dm	Evening Peak, Dm	
Total	Before	1182.4	2315.8	
	After	784.3	1741.2	
	Difference	-398.1	-574.6	
		-33.7%	-24.8%	
Average per Intersection	Before	78.8	154.4	
	After	52.3	116.1	
	Difference	-26.5	-38.3	
		-33.7%	-24.8%	

6.2 Economic Benefit from the Introduction of the ATC System

This chapter deals with the appraisal of the ATC system commissioned on April 1987 in terms of economic benefit.

Benefit is derived from the improvement in traffic conditions. Generally one of the benefits considered is the difference in delay times measured by the analysis of the "before and after study" data. The delay time can be converted to benefit in monetary value using the two aspects of time value and fuel consumption.

6.2.1 Procedure for Benefit Estimate

The procedure for benefit estimate is:

(1) Conversion from peak hour delay times to annual delay time
(2) Monetary conversion from annual delay time
(3) Benefit estimate for the ATC system

The following shows the methods and assumptions for each procedure.

A. Conversion from Peak Hour Delay Times to Annual Delay Time

For calculation of annual delay time, two processes were used:

- converting from morning and evening peak hour delay times to daily delay time.
- converting from daily delay time to annual delay time.

1) 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, 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 similar results.

The daily delay time can also be calculated by using only data of the morning and evening peak hour delay times, that is:

$$Dd = Dm + 8\,Do + De$$
$$= 4(Dm + De)$$

where Dd: daily delay time (8:00 to 18:00)

2) Annual Delay Time

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

B. Monetary Conversion from Annual Delay Time

The transport cost due to delay time can be measured using the time value for vehicle user and the cost of fuel consumption 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, the weighted time cost in the Study Area is estimated as M$3.80 per PCU hour. Fuel cost is estimated. 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 for one PCU vehicle is M$0.57 per hr.

C. Benefit Estimate for the ATC System

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

*Source: Klang Valley Transportation Study 1986

**Source: Association of Traffic Control Facility, Japan

6.2.2 Estimated Profit

Table 5 presents the results estimated for both "before and after study" according to the above mentioned procedure, and it also shows the difference between both studies.

A. Estimated Difference in Delay Time

The annual delay time for the fifteen (15) intersections are computed for "before and after" traffic conditions. The difference in delay time are then estimated and presented in Table 5. As the results indicate, the 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 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 ATC system could be expected to gain annual benefit of approximately (M$4.3 million) or to save 28% of the annual transport cost (M$15.3 million before the operation of the ATC System). Time value saving is M$3.7 million and fuel saving is M$0.6 million.

Table 5 Annual Delay Time and Annual Transport Cost 'Before' and 'After' Installation

	'Before'/ 'After' Installation	Delay Time (Hours)		Daily Delay Time (Hours)	Annual Delay Time 250 Days X 1000 Hr	Time Value M$3.80 per PCU hr M$ X 1000	Fuel Cost M$0.57 per PCU hr M$ X 1000	Annual Transport Cost M$ X 1000
		Morning Peak, Dm	Evening Peak, De					
Total For All Intersections	Before	1182.4	2315.8	13992.8	3498.2	13293.2	1994.0	15287.1
	After	784.3	1741.2	10102.0	2525.5	9596.9	1439.5	11036.4
	Difference	− 398.1	− 574.6	− 3890.8	− 972.7	− 3696.3	− 554.4	− 4250.7
		− 33.7%	− 24.8%	− 27.8%				− 27.8%
Average Per Intersection	Before	78.8	154.4	932.9	233.2	886.2	132.9	1019.1
	After	52.3	116.1	673.5	168.4	639.8	96.0	735.8
	Difference	− 26.5	− 38.3	− 259.4	− 64.8	− 246.4	− 37.0	− 283.4
		− 33.7%	− 24.8%	− 27.8%				− 27.8%

6.3 Conclusions of Penang ATC Project Evaluation

Traffic surveys "before" and "after" the installation revealed the following benefits: (See Figure 14)

- Reduction of travel times on major routes by approximately 16%
- Reduction of delay times at intersections by approximately 28%
- Annual benefit of approximately M$4.3 million

The total cost of the Penang ATC system was M$3.2 million (¥210 million). Of this amount, M$2.4 million (¥150 million) was borne by the Municipal Council of Penang Island and M$800,000 (¥60 million) was contributed by JICA. The investment cost was therefore recovered in nine months. Since benefits from the reduction in traffic accidents are non-quantifiable, they are not included. If such data was considered, it is likely that the benefits derived from the ATC system would be even greater.

Although the author of this paper was able to predict that the traffic control system would lead to certain improvements in traffic problems from his own experience, the benefits gained in Penang far exceeded his predictions. The implications of this are that dramatic results can be achieved if measures to deal with traffic problems, such as traffic control systems, are implemented at an early stage when traffic volume is low; the damage to society caused by such traffic problems can therefore be prevented. The positive effects of the Penang ATC system also confirmed the importance of the timing of traffic control plan implementation in improving traffic problems.

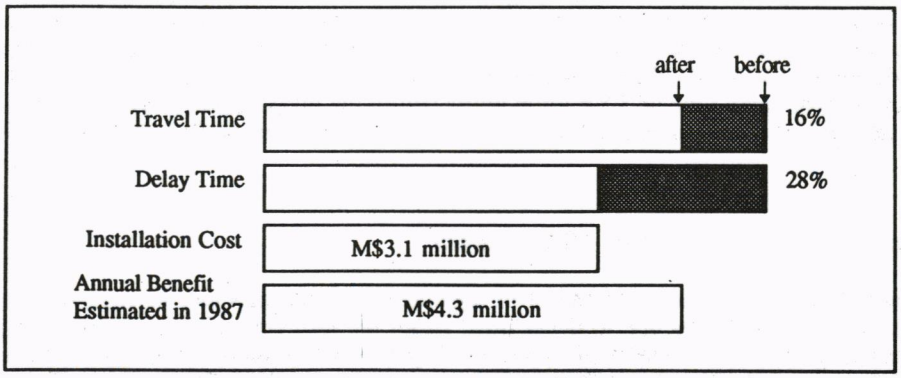


Figure 14 Comparison of "Before" and "After" Installation of Stage I of the ATC System

7. EXPANSION OF THE PENANG ATC SYSTEM AND FEASIBILITY STUDY

A survey team was dispatched from July 1986 to November 1987 by JICA. The purpose of this development study was to draw up comprehensive traffic control plans for the Penang State, and to consider the feasibility of expanding the computerized ATC system (Penang ATC Center) as part of these plans.

The final report made the following project proposals:

1. Plan for expansion of Penang ATC Center (See Figure 15)
2. Plan for extension of Weld Quay Road (highway)
3. Plan for construction of a new bus terminal in central George Town
4. Plan for construction of off-street multistory car parks
5. Plan for bus renewal

The Municipal Council of Penang Island has strongly requested that a survey be conducted into bus transport in the area. The possibility of such as survey needs to be considered.

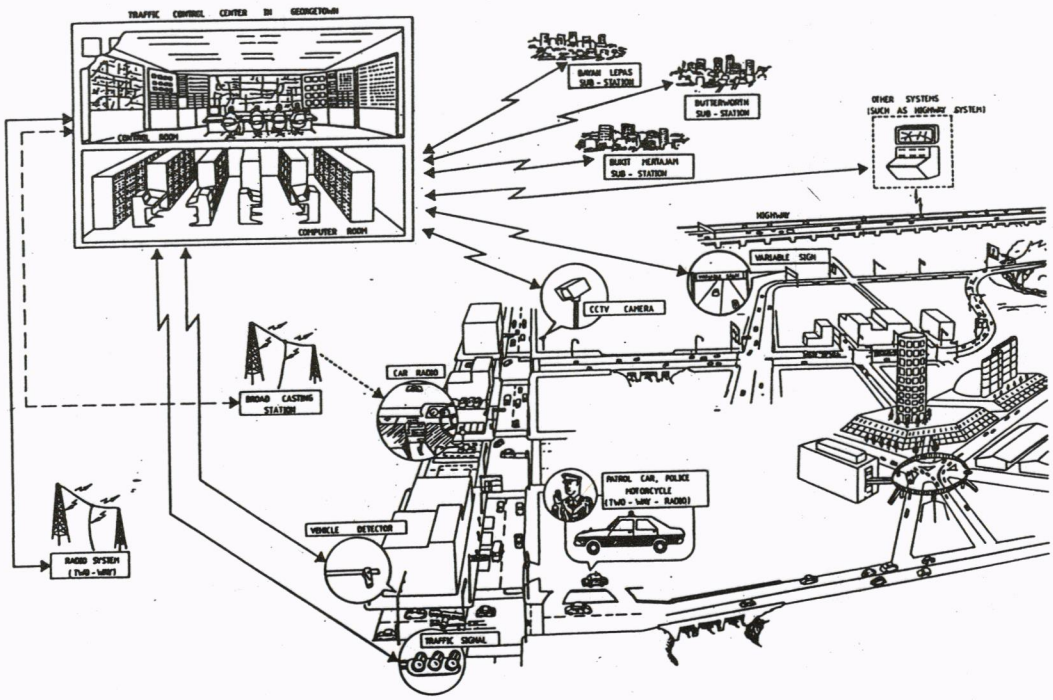


Figure 15 Overview of Penang State Traffic Control System (Future Stage)

8. PENANG URBAN TRANSPORTATION SYMPOSIUM

The Penang Urban Transportation Symposium was held jointly by the Municipal Council of Penang Island and JICA, and was chaired by the present author. Announcements were made and discussions were held regarding the progress of the Penang ATC project and the economic effects of Stage I of the project. The results of the survey of plans for extending the traffic control system were also announced by the JICA study team.

9. CONCLUSION

Technical cooperation in Penang traffic control planning has been continuing ever since the JICA survey team was first dispatched in 1979. Progress is also being made on Stages II and III of the project and on the expansion of the control area, as was mentioned in the survey report.

Traffic signals, centrally controlled at the Penang Traffic Control Center, have succeeded in dramatically improving traffic flow on the island, thus avoiding the problem of excess traffic inflow after the completion of large-scale urban development projects such as Penang Bridge and the KOMTAR complex. Japanese traffic control technology and traffic engineering have been highly acclaimed by the Municipal Council of Penang Island for contributing to these improvements.

Although the running of the traffic control center has been handed over to the Municipal Council of Penang Island, which administers the local traffic, management of the center for the time being and future plans for expansion of the system require continued backup from JICA.

The present author revisited Penang last year, and can confirm that the Penang ATC Center is functioning smoothly and that there have been no major breakdowns.

The yearly increases in traffic volume accompanying Malaysia's recent economic development are, however, causing traffic congestion to deteriorate in areas not covered by the ATC Center. Although there are many issues which need to be addressed—including economic and government policy problems, and obtaining the consensus of ordinary citizens—the author of this paper hopes that progress will be made towards the fulfillment of Stages II and III of this project and that as much support as is needed will be provided within the framework of the friendship that exists between the Municipal Council of Penang Island and the City of Yokohama.

There are also a variety of issues that need to be considered in the area of technological cooperation. JICA is, however, working toward solving these and to promoting technological cooperation not only in traffic engineering and urban traffic planning, but in all the areas in which the Malaysian government requests help. It is to be hoped that urban planning will contribute to the development of even closer ties between Japan and Malaysia.

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REFERENCE

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