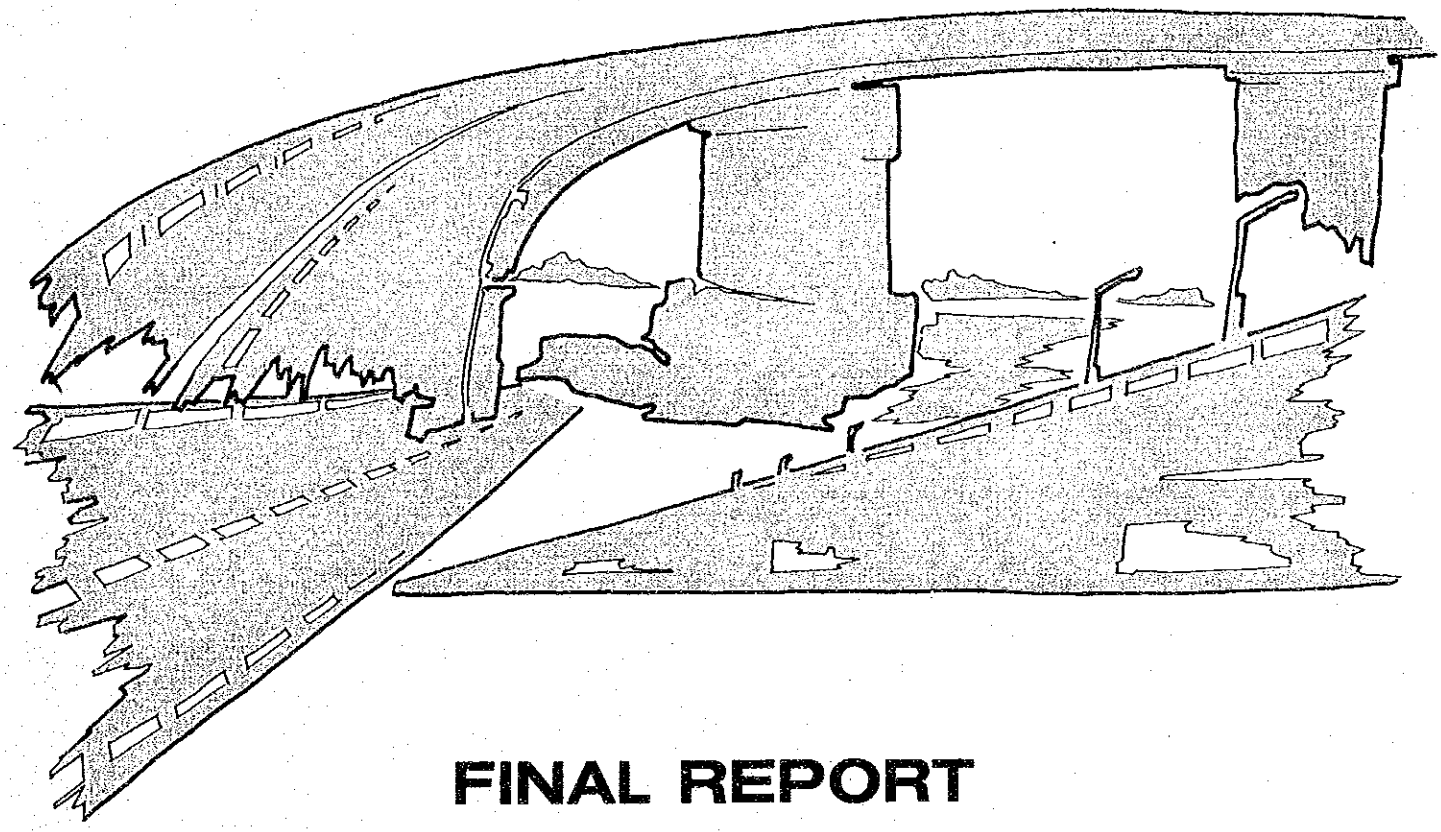
社会開発調査部報告書

No. 52

GOVERNMENT OF MALAYSIA
MALAYSIAN HIGHWAY AUTHORITY

LEMBAGA LEBUHRAYA MALAYSIA

STUDY ON TRAFFIC CONTROL AND MANAGEMENT SYSTEM OF MALAYSIAN EXPRESSWAYS AND TOLL HIGHWAYS



FINAL REPORT

SUMMARY AND RECOMMENDATIONS

DECEMBER 1989

JICA JAPAN INTERNATIONAL COOPERATION AGENCY

STUDY ON TRAFFIC CONTROL AND MANAGEMENT SYSTEM OF MALAYSIAN EXPRESSWAYS AND TOLL HIGHWAYS FINAL REPORT SUMMARY AND RECOMMENDATIONS DECEM

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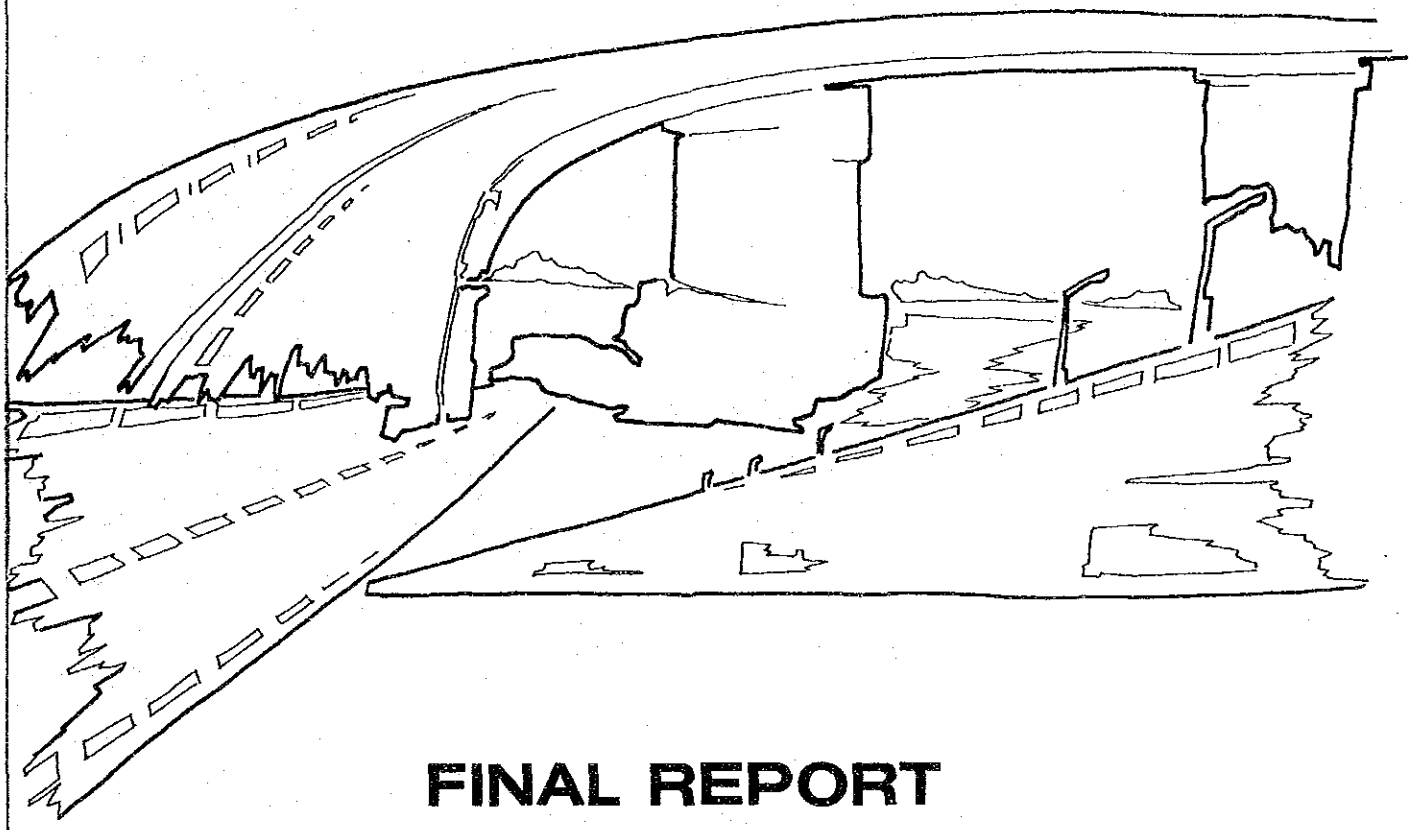

FINAL REPORT

SUMMARY AND RECOMMENDATIONS

DECEMBER 1989

JICA JAPAN INTERNATIONAL COOPERATION AGENCY

PREFACE

In response to a request from the Government of Malaysia, the Japanese Government decided to conduct a study on the Traffic Control and Management System of Malaysian Expressways and Toll Highways and entrusted the study to Japan International Cooperation Agency (JICA).

JICA sent to Malaysia a survey team headed by Mr. Kokuro Hanawa, Fukuyama Consultants International Co., Ltd. from December 1988 to September 1989.

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

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

I wish to express my sincerest appreciation to the officials concerned of the Government of Malaysia for their close cooperation extended to the team.

December, 1989

Kensuke Yanagiya

President

Japan International Cooperation Agency

CONCLUSIONS AND RECOMMENDATIONS

1.0 NEED TO INTRODUCE A TRAFFIC CONTROL AND MANAGEMENT SYSTEM TO THE MALAYSIAN EXPRESSWAY AND HIGHWAY

Expressway traffic control and management system is a system that utilizes traffic surveillance and control measures to control and regulate traffic; maintains the highway facilities in good condition and mobilizes personnel to overcome any unforseen incidents on the expressway. The goals of such a system are to:

a) achieve maximum traffic safety on the expressway,
b) ensure smooth flow of traffic along the entire expressway network, and
c) provide a comfortable and conducive environment for the drivers.

In more specific terms, the system is aimed at achieving the following objectives:

a) Reducing recurring highway congestions,
b) Minimizing effects of non-recurring incidents,
c) Maximizing safety on traffic operation,
d) Providing highway users with up-to-date information on traffic and road conditions,
e) Rendering aid to those who have encountered difficulties on the highway (accidents, breakdowns, sickness, etc.),
f) Maintaining the highway and all its related parts and facilities in good condition at all times.

With the North-South expressway scheduled to be fully completed and operational by 1995, it is timely now that a traffic control and management system capable of achieving the above goals and objectives be introduced to the network. Traffic growth on the completed sections of the expressway has already been rather substantial particularly those around the metropolitan area of Kuala Lumpur. Once fully operational in 1995, high traffic volume plying between major urban centers can be expected as benefits accruing from the use of the expressway network become more profound. Moreover, with the introduction of the traffic control and management system, traffic operation and hence safety on the expressway will be greatly enhanced, thus inducing even more users. The efficient operation of these nation wide arteries will give a further boost to the Malaysian social and economic development. The Malaysian Highway Authority (MHA), vested with the responsibility of overseeing the construction and the management of the expressway network in Malaysia, should therefore take steps now towards the implementation of the proposed traffic control and management system.

2.0 PROPOSED TRAFFIC CONTROL AND MANAGEMENT SYSTEM

1) Functions of the System

The proposed traffic control and management system has four major functions, namely, information collection, information processing, information dissemination as well as execution and enforcement.

Information collection function is to gather traffic data and incident information through emergency telephone, vehicle detector, weather observatory equipment and close-circuit television camera as well as patrol car.

Information processing function is to process and analyze the above-mentioned collected data and information and subsequently display them in a manner that traffic management activities can be activated.

Information dissemination function is to convey road and traffic conditions to road users through changeable message sign, changeable speed limit sign, highway radio and information counter at service area.

Execution and enforcement function is to ensure coordinated execution of traffic control and management measures such as countermeasure against incidents, maintenance and repairs.

2) The System in Relation to the Expressway Network

The proposed traffic control and management system consists of two interlinked systems in order to accommodate the needs and aspirations of two different bodies. One system which covers the North-South Expressway, Senai-Johor Bharu Highway, New Klang Valley Expressway and Federal Highway (Subang-Klang) is under the responsibility of the concession company named Projek Lebuhraya Utara-Selatan (PLUS) whilst the other which covers Penang Bridge and Karak Highway is under the responsibility of Malaysian Highway Authority (MHA).

3) Organization Set-up

In order to facilitate effective traffic control and management of the expressway and toll highway network, a three (3) division plan consisting of a northern region, a central region and a southern region is recommended for the North-South Expressway, New Klang Valley Expressway, Federal Highway and Senai-Johor Bharu Highway. The traffic control centers and sub-centers are recommended to be located in the PLUS's regional and maintenance offices respectively. For Penang Bridge and Karak Highway which are under the direct management of MHA, the traffic control centers should be provided in the maintenance offices. Both the PLUS and MHA traffic control centers are closely interlinked to facilitate information exchange and cooperative efforts during any emergencies.

4) Traffic Management Levels

To meet the diverse requirements of different type and section of the expressway, three traffic management levels are recommended. Each expressway section is assigned a particular level, largely depends on the traffic volume. Level 1 is applied to sections having daily traffic volume lower than 30,000 veh/day on a 4-lane highway. Level 2 is applied to sections with volume between 30,000 and 50,000 veh/day while Level 3 is adopted to sections when the traffic volume reaches 50,000 veh/day and beyond.

5) Traffic Control and Management System Equipment

To accomplish the functions of the system, various roadside equipment consisting of 1,339 emergency telephones, 178 vehicle detectors, 13 weather observatory equipment, 12 close-circuit television cameras, 207 changeable message signs, 46 changeable speed limit signs and highway radio (Kajang-Bangi section) are installed at various locations along the expressway network. They are controlled either by the traffic control centers or sub-centers. The control center acts as a core of the traffic control and management system and accommodates a computer system and other associated equipment. A communication network with 845 km of cable is established between the roadside equipment and centers as well as between the centers and sub-centers (see Table 1).

Table 1 : Proposed Traffic Control and Management System Equipment

Equipment	Unit	North-South Expressway	Senai-Johor Bharu Highway	New Klang Valley Exp.	Federal Highway	Penang Bridge	Karak Highway
1. Information Collection System							
1.1 Emergency Telephone	No.	1190	-	104	-	-	45
1.2 Vehicle Detector	No.	96	2	42	8	22	8
1.3 Weather Observatory Equipment	No.	12	-	-	-	-	1
1.4 Close-Circuit Television Camera	No.	3	1	3	1	2	3
2. Information Dissemination System							
2.1 Changeable Message Sign(Mainline)	No.	20	-	5	-	3	-
(Access Road)	No.	4	-	8	-	2	-
(Toll Gate)	No.	128	5	11	12	4	4
(Tunnel)	No.	4	-	-	-	-	2
2.2 Changeable Speed Limit Sign	No.	46	-	-	-	-	-
2.3 Highway Radio		-	-	-	-	-	-
3. Information Processing System							
3.1 Control Center	No.	2	-	1	-	1	1
3.2 Sub-center	No.	9	-	-	-	-	-
4. Communication System							
4.1 Communication Cable	km	768	-	34	-	-	43

6) Interface with Other Traffic Control Systems

It is imperative to link the proposed traffic control and management system with other similar systems especially in the vicinity of Kuala Lumpur Conurbation for effective traffic control and management as the traffic flow are closely interrelated. As such, it is recommended to link the proposed system with the Kuala Lumpur Area Traffic Control (ATC) System, Petaling Jaya Area Traffic Control (ATC) System and Highway Traffic Surveillance (HTS) System for Federal Highway (Subang-Kuala Lumpur) which were recommended in the Feasibility Study of Transportation Facilities Projects in Klang Valley.

3.0 ESTIMATED SYSTEM COSTS

The proposed traffic control and management system is estimated to cost a total sum of M$376.8 million at 1989 prices. The system construction cost for the North-South Expressway and other routes under the management of PLUS is estimated at M$342.6 million. The system construction cost for Karak Highway and Penang Bridge is estimated at M$34.2 million (see Table 2).

The cost for the communication system takes up some 60% of the total system construction cost. This communication system can be enlarged to provide nation wide transmission purposes, and in which case, this item may be viewed as a national resource to be invested by the telecommunication agency. The construction cost for the system by the management body can therefore be substantially reduced. It is suggested that for the sections yet to be constructed, part of the communication system work, namely trenching and conduit works, be included in the road construction work. The works will be easier and faster if well programmed and the system cost could be reduced.

The annual operation cost for the total system by 1995 (Stage 2) is estimated to be M$20.1 million. The annual operation cost for the North-South Expressway and other routes under PLUS's management is estimated at M$17.6 million whilst that for Karak Highway and Penang Bridge is M$2.5 million (see Table 3).

Table 2: Construction Cost Estimates by Stage

Unit:M$'000

Route/Section	Length (km)	Stage 1	Stage 2	Stage 3	Total
NORTH-SOUTH EXPRESSWAY	758.2	100,888	192,804	14,595	308,289
SENAI HIGHWAY	28.0	290	667	515	1,472
NEW KLANG VALLEY EXP.	53.6	0	27,641	3,396	31,037
FEDERAL HIGHWAY	15.0	0	1,286	517	1,802
Sub-total	854.8	101,178	222,398	19,023	342,600
PENANG BRIDGE	14.0	9,756	2,400	981	13,137
KARAK HIGHWAY	46.8	19,080	1,940	0	21,020
Sub-total	60.8	28,837	4,340	981	34,157
Total	915.6	130,015	226,738	20,004	376,758

Notes: 1) New Klang Valley Expressway includes 16.6 km of N-S Expressway (Rawang-Bukit Lanjan section).
2) Length of Karak Highway is the stretch between toll plaza.

Table 3: Annual Operation Cost at Each Stage

Unit:M$'000

Route/Section	Length (km)	Stage 1	Stage 2	Stage 3
NORTH-SOUTH EXPRESSWAY	758.2	5,461	15,614	16,228
SENAI HIGHWAY	28.0	21	193	208
NEW KLANG VALLEY EXP.	53.6	0	1,660	1,845
FEDERAL HIGHWAY	15.0	0	131	149
Sub-total	854.8	5,482	17,598	18,430
PENANG BRIDGE	14.0	1,044	1,151	1,200
KARAK HIGHWAY	46.8	1,284	1,364	1,364
Sub-total	60.8	2,328	2,515	2,564
Total	915.6	7,810	20,113	20,994

Notes: 1) New Klang Valley Expressway includes 16.6 km of N-S Expressway (Rawang-Bukit Lanjan section).
2) Length of Karak Highway is the stretch between toll plaza.

4.0 EVALUATION OF SYSTEM

1) Benefits to Motorists and Road Administrator

The proposed traffic control and management system is anticipated to contribute various qualitative and quantitative benefits to motorists. As an initial step, it will render any kind of assistance to the motorist in a timely manner and alleviate their irritation. More specifically, the proposed system is capable of conveying information to drivers to facilitate their decision in taking detour or changing travel plan. Besides, the proposed system is expected to reduce accident rate, congestion, delay, travel time and environmental pollution as well as prevent the occurrence of secondary incident.

In addition to these direct benefits to the motorists, the road administrator can grasp traffic and road condition on a real time basis and the collected data is useful for evaluation and planning of future traffic management policy, safety countermeasures, traffic regulation and road improvements.

2) Cost Comparison

The magnitude of the proposed system cost is within reasonable range as revealed by the cost comparison analysis. Firstly, the ratio of the system construction cost to the road construction cost is approximately 8% which is deemed reasonable from similar comparison analysis in other countries. Secondly, the necessary toll increase with the introduction of the proposed system if the cost need to be borne by the users is only about 8.0%. Lastly, the construction cost and operation costs is comparatively low compared with the vehicle running cost on toll roads.

In short, comparing the system construction and operation costs with the other costs related to toll roads and considering the benefits realized by the system, the costs incurred by the introduction of the system is well within the reasonable range and motorists may be able to afford it should the cost be borne by them.

5.0 IMPLEMENTATION PROGRAMME

The implementation programme for stages 1 and 2 to be implemented by 1995 is shown here. Stage 3 is to be implemented by 2005 (see Figure 1).

Section/Route	1990	1991	1992	1993	1994	1995
Alor Setar	+++++++	**********			+++	**********
Butterworth				+++++++		**********
Taiping				+++++++		**********
Ipoh				+++++++++		**********
Tanjung Malim				+++++++		**********
Kajang	++++++	**********			+++	**********
Ayer Keroh	+++++++++	**********			+++	**********
Air Hitam			+++++++	**********		
Skudai			++++++	**********		
New Klang Valley Ex'way	+++++++	**********				
Penang Bridge	++++	**********			+++	**********
Federal Highway		+++	**********			
Senai Highway	+++	**********			+++	**********
KL - Karak Highway	+++++	**********			+++	**********

Note: ++++: Detailed Design
****: Construction Work

Figure 1: Implementation Programme

In accordance with the implementation program, annual financial requirement is calculated assuming that the cost is incurred uniformly during the construction period. Detailed design cost, system operation cost and other project management costs are not included. A total sum of M$354.8 million is required by 1995 for the implementation of Stages 1 and 2. The column under "1996-" indicates the cost for Stage 3 system, which will be incurred during the years 1996 through 2005 (see Table 4).

Table 4: Annual Financial Requirement

Unit:M$ Million

	Annual Financial Requirements						
Route	1991	1992	1993	1994	1995	1996-	Total*
Toll roads operated by concession company (North-South Expressway, Senai Highway, New Klang Valley Expressway, Federal Highway)	34.4	84.6	22.5	82.3	99.9	19.2	342.7
Penang Bridge	6.5	3.3	-	-	2.4	1.0	13.1
Karak Highway	9.5	9.5	-	-	1.9	-	21.0
Total	50.4	97.4	22.5	82.3	104.2	20.2	376.8

* Figures are rounded up

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1.0 INTRODUCTION

1.1 Background

A new road transport era was launched with the construction of North-South Expressway which is planned and designed to satisfy the need to move goods and people swiftly and safely between the major cities in Peninsular Malaysia.

The need for a highway traffic control and management system is recognized in view of the development and expansion of expressway network in the country, the rapidly growing traffic demand and the increasing awareness for efficiency and safety by the expressway users.

The Government of Malaysia thus requested the Government of Japan to extend the necessary technical assistance in establishing a traffic control and management system masterplan for the Malaysian expressways and toll highways. In response to such a request from the Government of Malaysia, the Government of Japan through the Japan International Cooperation Agency (JICA), which is responsible for the implementation of technical cooperation programmes of the Government of Japan, has sent a team of experts to Malaysia to conduct the Study on Traffic Control and Management System of Malaysian Expressways and Toll Highways. This Study was conducted in close collaboration with Malaysian Highway Authority (MHA). It officially commenced on December 1988 and has taken one year to complete.

1.2 Objectives

The objectives of the Study are:

a) to formulate a traffic control management plan (including short-term and long-term plans) of expressways and toll highways as specified within the Study Area.

b) to prepare an operation manual on the proposed traffic control and management system of expressways and toll highways in Malaysia.

1.3 Study Routes

The Study Area covers the expressways and toll highways under the jurisdiction of the Malaysian Highway Authority as shown in Figure 1 and Table 1.

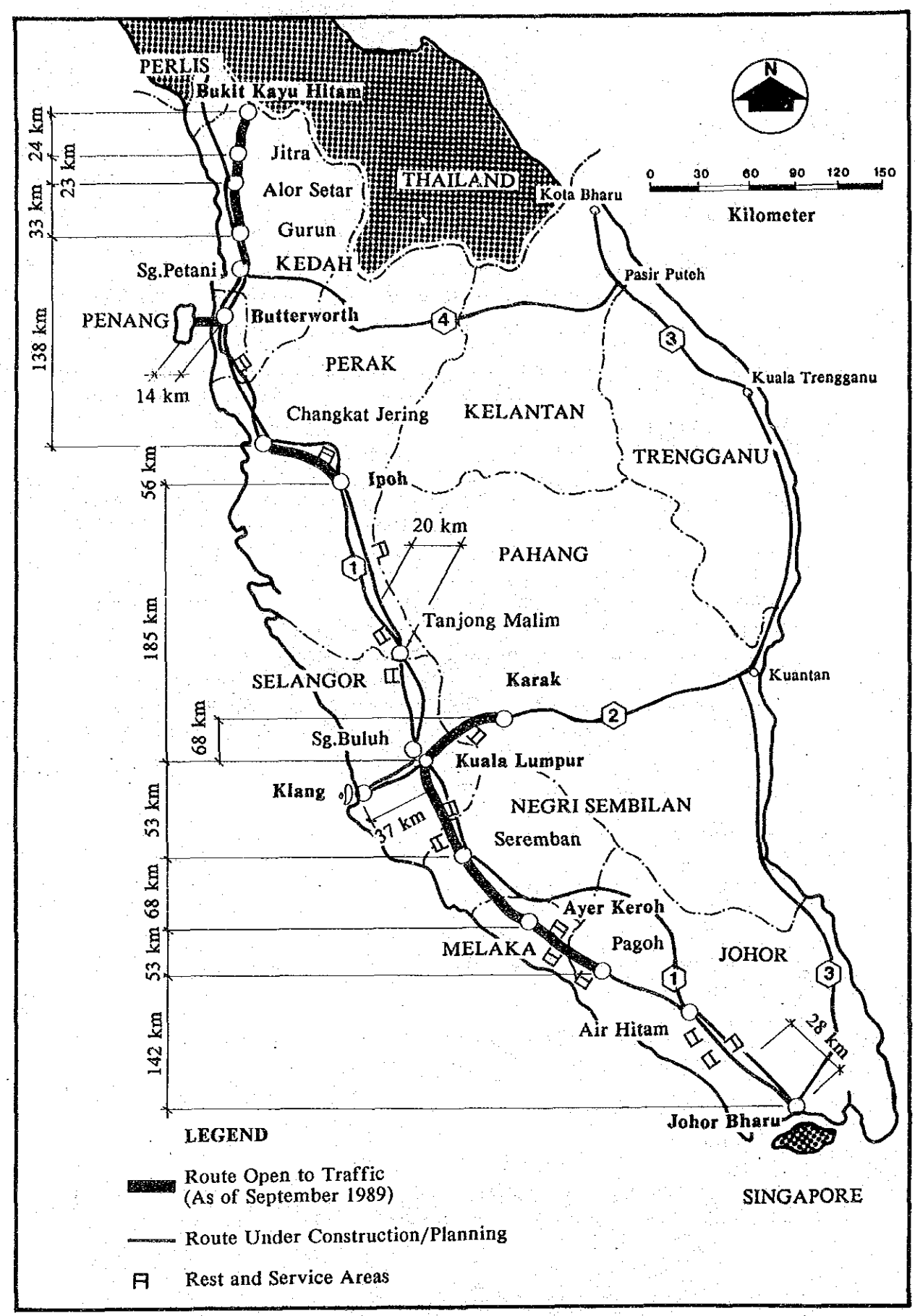


Figure 1: Route Map of Expressways and Toll Highways Under this Study

Table 1: Route/Sections of Expressways and Toll Highways under this Study

Route/Sections	Approximate Length in km
NORTH-SOUTH EXPRESSWAY	
1. Bukit Kayu Hitam - Jitra	24
2. Jitra - Butterworth	107
3. Butterworth - Changkat Jering	87
4. Changkat Jering - Ipoh	56
5. Ipoh - Tanjung Malim	125
6. Tanjung Malim - Kuala Lumpur	60
7. Kuala Lumpur - Seremban	53
8. Seremban - Air Hitam	182
9. Air Hitam - Kota Tinggi	81
Sub-total	775
OTHER TOLL EXPRESSWAYS	
10. New Klang Valley Expressway	37
11. Penang Bridge	14
Sub-total	51
TOLL HIGHWAYS	
12. Kuala Lumpur - Karak	68
13. Senai - Johor Bharu	28
14. Improvement of Federal Highway (from Subang International Airport to Berkeley Roundabout)	15
Sub-total	111
TOTAL	937

The Study includes three expressways namely the North-South Expressway, New Klang Valley Expressway and Penang Bridge; and three toll highways namely Kuala Lumpur-Karak Highway, Senai-Johor Bharu Highway and improvement of Federal Route 2 from the Berkeley Roundabout in Klang to Subang.

The North-South Expressway is planned as a main interurban trunk route to run along the west coast of Peninsular Malaysia from the border with Thailand southward to Singapore. The total length of the North-South Expressway is approximately 775 km. In August 1989, about 310 km has been opened to traffic and the whole stretch is scheduled to be completed and operational by 1995.

In 1988, the North-South Expressway together with the New Klang Valley Expressway, Federal Route 2 (also known as Federal Highway)(from Berkeley to Subang) and Senai-Johor Bharu Highway were privatized under the Malaysian Government's Privatization Policy. Under the Concession Agreement, the private concession company is responsible for the design, construction, management, operation and maintenance of these expressway routes while MHA is to play the monitoring, control, supervisory and advisory role to the concession company.

The Penang Bridge, a 14 km bridge structure completed in 1985, links Penang Island with the main land. The Kuala Lumpur-Karak Highway is part of the Federal Route 2 which traversed Peninsular Malaysia from west to east. Both these routes remain under the direct management of the Malaysian Highway Authority.

1.4 Study Approach

This Study was conducted in three (3) phases (Figure 2).

Phase I, from December 1988 to March 1989, carried out works involving the collection and analysis of relevant data and information/reports. This led to the identification of existing problems and issues which then culminated in the proposal of a traffic control and management system masterplan for the Malaysian expressways and toll highways.

Phase II, from May to mid-September 1989, conducted works as the setting of traffic control and management system design standards, the preliminary engineering design of various installations in the proposed traffic control and management system; preparation of an operation manual and lastly the evaluation of the proposed system.

Lastly, Phase III involved the preparation of the Final Report in Japan based on the Draft Final Report after receiving comments from the Malaysian Government.

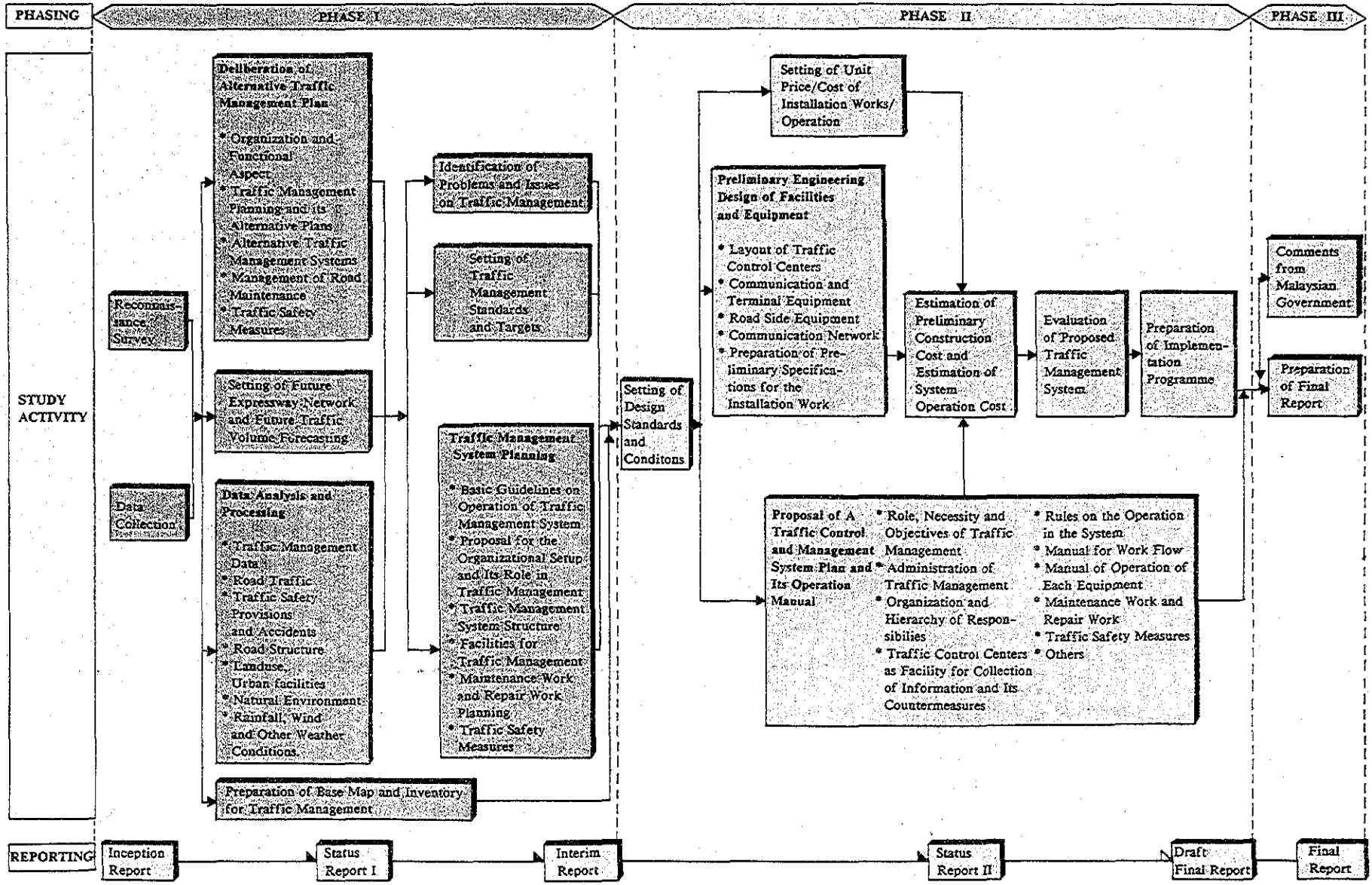
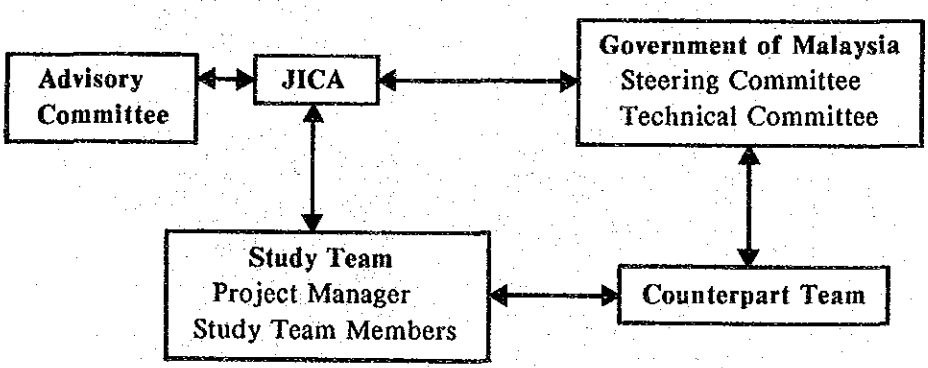


Figure 2: Study Approach

1.5 Organization of the Study

This study was carried out jointly by Japan International Cooperation Agency (JICA) and the Government of Malaysia in coordination with other related agencies. JICA has set up an Advisory Committee in providing advice and suggestions through several steering committee meetings during the study period. The organization for the study and the lists of committees and their members are as follows:



Steering Committee, Government of Malaysia

Chairman	Dato' Mustaffa bin Ahmad	Malaysian Highway Authority
	Mr.Yeoh Eng Hun	Malaysian Highway Authority
	Mr.Mohammad bin Abdul Majid	Malaysian Highway Authority
	Mr.Chua Lee Boon	Malaysian Highway Authority
	Mr.Ismail Mohammad	Economic Planning Unit, Prime Minister's Department
	Puan Wan Norma bt Wan Daud	Economic Planning Unit, Prime Minister's Department
	Puan Rohani Omar	Economic Planning Unit, Prime Minister's Department
	Mr.Chew Swee Hock	Road Section, Public Works Department

	Mr.Zainal Abidin Ahmad	Road Section, Public Works Department.
	Mr.Heng Aik Koon	Highway Planning Unit, Ministry of Works.

Technical Committee, Government of Malaysia

Chairman	Ir.Yeoh Eng Hun	Malaysian Highway Authority
	Ir.Chua Lee Boon	Malaysian Highway Authority
	Ir.I.Dorairajoo	Malaysian Highway Authority
	Ir.Abdul Adzim Muhammad	Malaysian Highway Authority
	Ir.Zakaria Mat Nor	Malaysian Highway Authority
	Ir.Ismail Mohd.Salleh	Malaysian Highway Authority
	Ir.Mohd.Azman Ahmad	Malaysian Highway Authority
	Mr.Takeichi Sekiguchi	Malaysian Highway Authority
	Mr.Hirotaka Yamamura	Malaysian Highway Authority
	Mr.Taichi Seki	Highway Planning Unit
	Mr.Heng Aik Koon	Highway Planning Unit
	Mr.Zainal Abidin Ahmad	Public Works Department

Malaysian Counterpart Engineers

	Mr.Wan Shaari Wan Hassan	Malaysian Highway Authority
	Mr.Zailan Ramli	Malaysian Highway Authority

Advisory Committee, Government of Japan

Chairman	Mr.Hisakazu Oishi	Ministry of Construction
	Mr.Hiroshi Aoki	Japan Highway Public Corporation
	Mr.Hiroshi Kikkawa	Metropolitan Expressway Public Corporation

Study Team

Japanese Expert

Team Leader	Mr.Kokuro Hanawa	Traffic Control and Management System Planning
	Mr.Michimasa Takagi	Traffic Management Planning
	Mr.Takashi Sato	Traffic Control and Surveillance System Design (I)
	Mr.Seiya Matsuoka	Traffic Control and Surveillance System Design (II)
	Mr.Akira Okita	Highway Facility/Maintenance Planning
	Mr.Yutaka Yamaguchi	Traffic Operation Planning
	Mr.Takasuke Tanno	System Design/Cost Estimate
	Mr.Tadamichi Hoshi	Traffic Safety Planning
	Mr.Chua Mok You	Transport Planning

Malaysian Engineer

	Mr.Ooi Peng Hong	Transport Planning

Embassy of Japan

Mr.Hirofumi Ohnishi	
Mr.Shunichi Hamada	

Japan International Cooperation Agency

Mr.Atsushi Matsumoto	Coordinator JICA Headquarters
Mr.Keizo Kagawa	Coordinator JICA Malaysia Office
Mr.Kuniaki Nagata	Coordinator JICA Malaysia Office

2.0 IDENTIFICATION OF PROBLEMS AND ISSUES ON TRAFFIC MANAGEMENT

2.1 Existing Condition and Identification of Problems

1) Existing traffic condition and current status of traffic management

a) Existing Traffic Condition

The average annual daily traffic volume (AADT) on the North-South Expressway operational sections and toll highways for 1988 is shown in Figure 3. The highest traffic volume is some 35,700 veh/day along the Kuala Lumpur-Kajang section of the North-South Expressway.

In terms of traffic composition, motorcycle forms a distinctive share of traffic on Penang Bridge (about 40%) and Alor Setar-Gurun section (about 22%) while trucks constitute a high proportion of traffic on Kuala Lumpur-Ayer Keroh section and Karak Highway.
The hourly traffic variation reveals that there is considerable commuter traffic (distinctive 2-peak pattern) on the Penang Bridge, Senai-Johor Bharu Highway and Kuala Lumpur-Seremban section while interurban traffic (evenly distributed pattern) are observed on Karak Highway, Alor Setar-Gurun, Changkat Jering-Ipoh and Seremban-Ayer Keroh stretches of the North-South Expressway.

Generally, on the opened expressway/highway sections, the month of December consistently shows up as the month throughout the year that has the highest traffic volume coinciding with the holiday season. In general, all sections of expressways and highways share significant increase of traffic on weekends.

With regard to travel speed on the expressway and highway, speed differences between vehicle type are most profound on Karak Highway compared to other sections. The survey results also reveal a vast difference in maximum and minimum speed of heavy trucks in both stretches of expressway and highways, especially on Karak Highway.

b) Current Status of Traffic Management

The Malaysian Highway Authority (MHA) directly maintains and manages the Karak Highway and Penang Bridge as well as oversees the performance of the concession company (called PLUS in short) in accordance to provisions in the Agreement covering all their

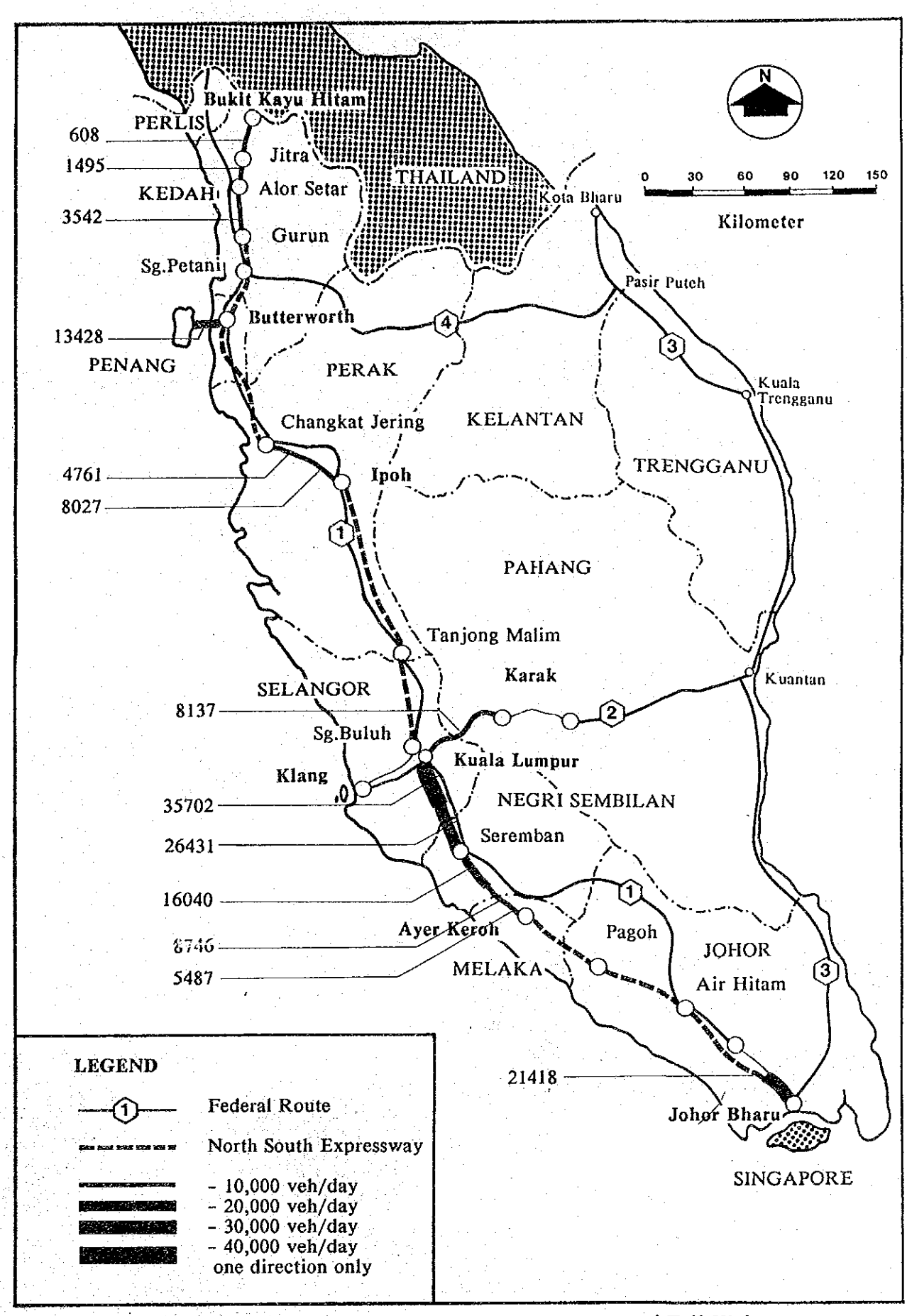
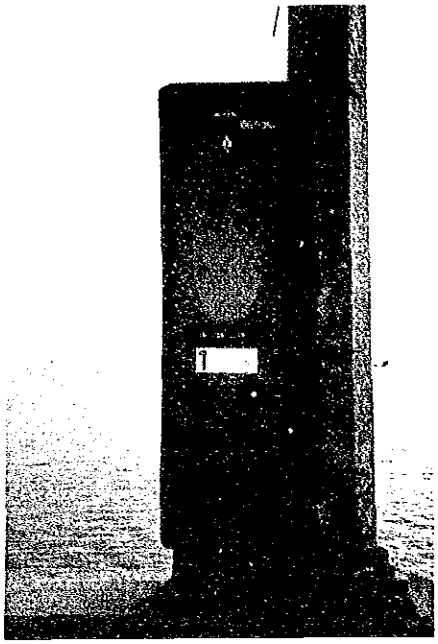
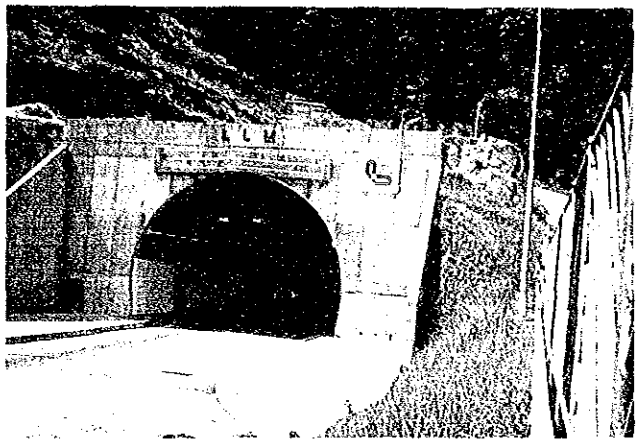
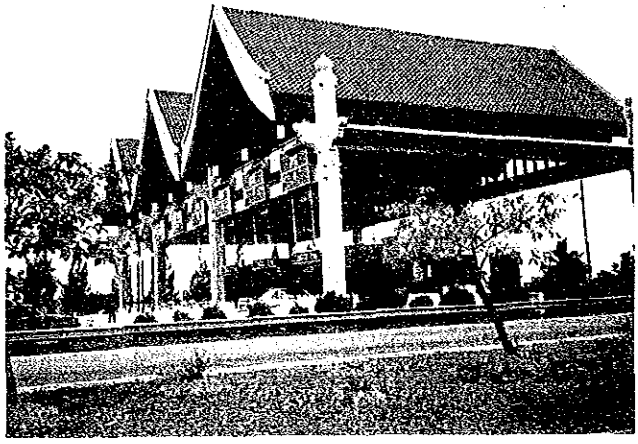


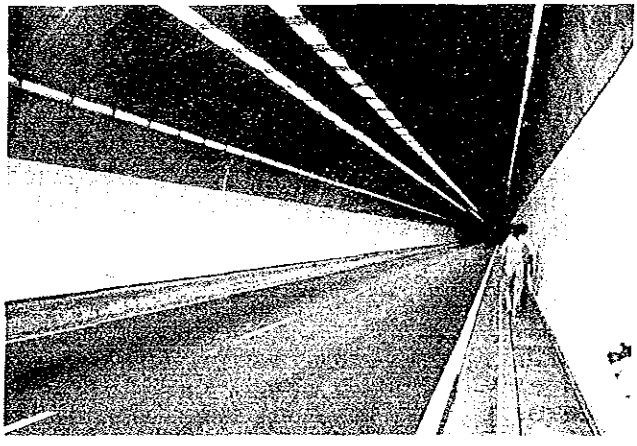
Figure 3: AADT Volume on the North-South Expressway and Toll Highway

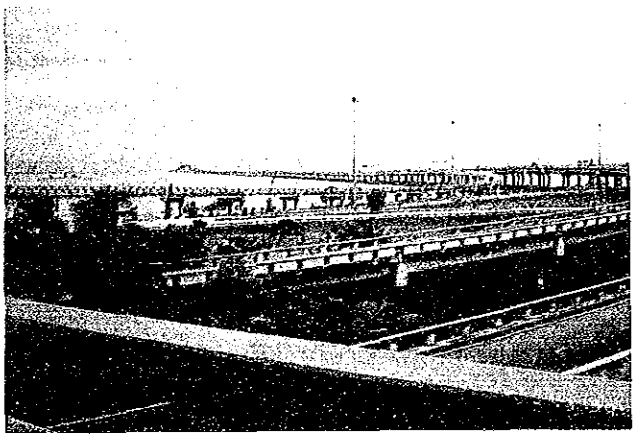
Photo Sheet A







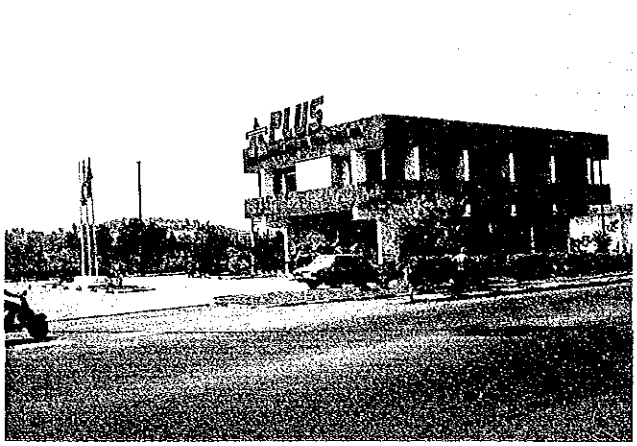


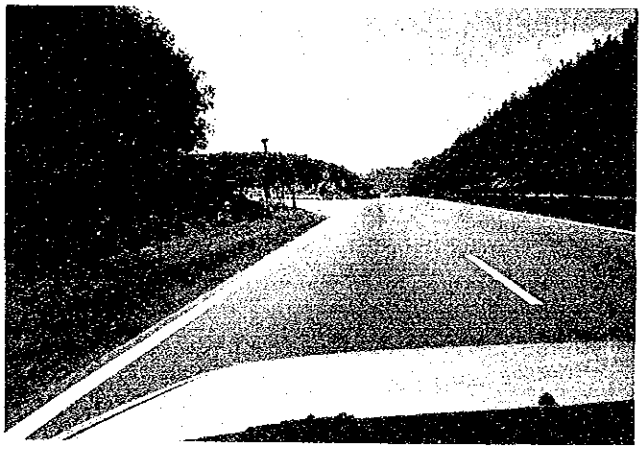


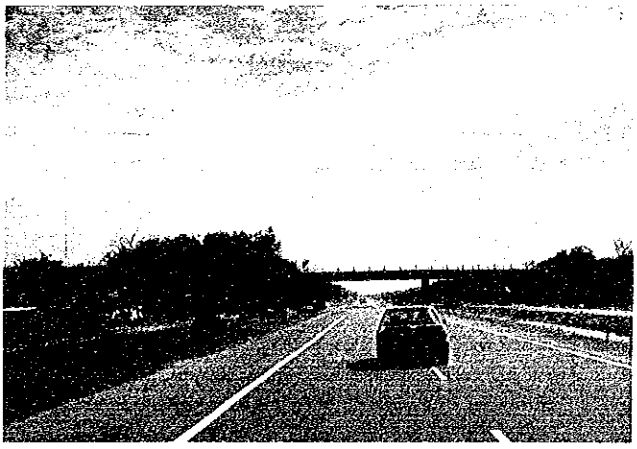
1 2 3 4 5 6 7

1. User-select push button type of emergency telephone installed along Penang Bridge.
2. Toll plaza at Penang Bridge.
3. An overall view of Penang Bridge and its approach from the Island.
4. Section of the North-South Expressway between Bukit Kayu Hitam and Jitra where there is no access control.
5. Entrance to the double-bore Menora Tunnel.
6. The Menora Tunnel is bright and with wall linings. The tunnel lighting is automatically adjusted to the brightness outside.
7. One of the poorly treated steep embankment slope along the Jelapang-Changkat Jering Section along the North-South Expressway.

Photo Sheet B







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1. Toll office at Sungei Besi Toll Barrier.
2. An example of poor implementation of traffic control measure during facility maintenance work.
3. Insufficient taper for exiting to one of the fuel station along the Kuala Lumpur-Seremban Expressway.
4. Intrusion by animals into the expressway along the Senawang-Ayer Keroh Section is a potential accident hazard to road users.
5. Intrusion by human is also a problem along the Kuala Lumpur-Seremban Expressway. Notice the unpaved road shoulder.
6. An accident that occurs on the expressway.
7. Enforcement on over speeding on the expressway.

responsibilities and obligations. PLUS is fully responsible for the financing, construction, maintenance and operation of the North-South Expressway, New Klang Valley Expressway, Federal Route 2 (Berkeley to Subang) and the Senai-Johor Bharu Highway.

Presently, the MHA management structure consists of the headquarters in Kuala Lumpur, four (4) regional offices, two (2) maintenance depots and one (1) tunnel control office. The other tunnel control office is under the jurisdiction of PLUS. Apart from these offices, toll plazas are set up to collect toll and perform traffic operation at Penang Bridge and Karak Highway. PLUS however is still in the process of setting up a concrete management structure consisting of a headquarters in Kuala Lumpur, three regional offices and some 15 maintenance offices.

Within the existing set-up, a highway police unit seconded from the Royal Malaysian Police Force performs the dual duties of highway patrol and enforcement of traffic regulations on all the expressways and toll highways.

Since only a few sections of the North-South Expressways and the toll highways have been opened to traffic, the status of traffic operation, i.e. traffic surveillance and traffic control is still in the infant stage. In the field of traffic surveillance, the present data collection system consists only of information gathering from emergency telephones located on certain expressway stretches, daily patrolling on only a few sections and traffic volume detectors installed at toll gates and barriers. Consequently, the related data processing and information dissemination system cannot be established. For communication, the existing network only made use of the public telephone line.

On traffic control, measures taken are daily patrolling, enforcement of speed limit and overloading vehicle. To cope with unusual conditions, a version of traffic control measure with its communication flow network is recently set up for the Kuala Lumpur-Ayer Keroh Expressway.

Apart from the above-mentioned traffic operation; traffic management on expressways also encompasses maintenance activities such as daily inspection, periodical maintenance, improvement and disaster prevention/ restoration or incidental maintenance. Currently, effort is being undertaken to produce a common maintenance manual for use by MHA and PLUS.

2) Existing Problems

Based on the analyses of existing traffic and road conditions, the present problems are elucidated.

a) Problems on the operational sections of the North-South Expressway

The following problems are found on some sections of the North-South Expressway:

i) High Accident Rate

ii) Unsatisfactory Road Conditions
* Unsatisfactory Geometric Designs
* Unavailability of Road Shoulder Pavement for Motorcyclist
* Insufficient Length of Acceleration Lane

iii) Shortcoming of Safety Facility
* Different Standard of Road Marking
* Lack of Uniformity in Guide Signs
* Lack of Optical Guidance
* Absence of Warning Signs/Devices for Strong Wind

iv) Frequent Occurrence of Vehicular Breakdown

v) Problems on Traffic Operation
* Inadequate Emergency Telephone Service
* Low Frequency of Patrol
* Inadequate Traffic Control Measure In Case of Accidents
* Absence of Efficient Communication Means

vi) Bad Driving Habits
* Dangerous Driving
* Lack of Information and Knowledge of Safe Driving on expressways

vii) Intrusion by Animals and Humans

b) Problem on Toll Highways

i) Problems on Karak Highway

* High Accident Number
* Deficiency in Road Conditions
  - Poor Geometric Design
  - Poor Road Pavement
* Shortcoming of Safety Facility
* Occurrence of Vehicular Breakdown
* Conspicuous Traffic Characteristics
  - Large Differences in Vehicular Speed Gap
  - Overloading of Lorry
* Dangerous Overtaking
* Absence of Proper Traffic Control Measures in Case of Accident
* Absence of Proper Communication Means
* Unsatisfactory Tunnel Condition

ii) Problems on Federal Highway (Federal Route 2)

* Unsatisfactory Road Condition
  - Narrow Traffic Lane
  - Absence of Clearance between Side Marking and Median
  - Unpaved Road Shoulder
* Mixed Traffic
  - High Volume of Motorcycle
  - Improper Riding Habit of Motorcyclists
* Recurrent Traffic Congestion
* Lack of First Aid Countermeasure

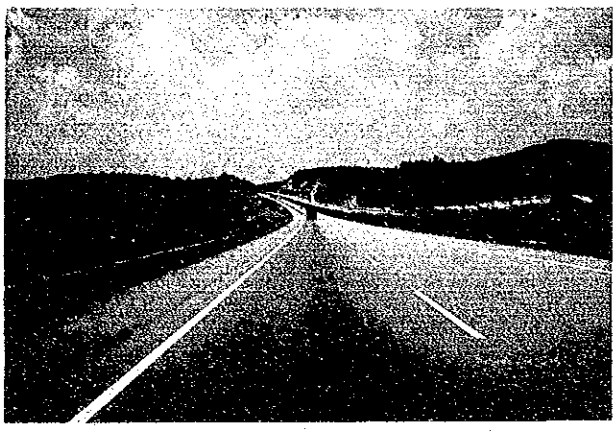
iii)Problems on Penang Bridge

* Large volume of motorcycles.
* Frequent parking offenders on the mid-span of bridge
* Large joint gap between bridge and embankment
* Frequent occurrence of vehicular breakdown

iv)Problems on Senai-Johor Bharu Highway

* Connected to local access roads by at-grade intersections
* Many parked vehicles for loading and unloading activities
* High volume of pedestrian crossing
* Insufficient safety facilities

Photo Sheet C



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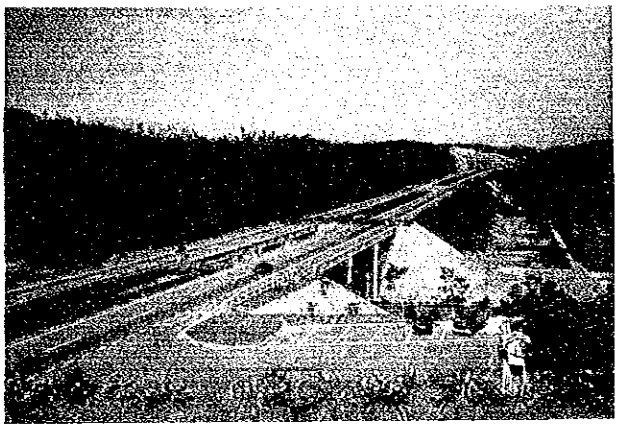
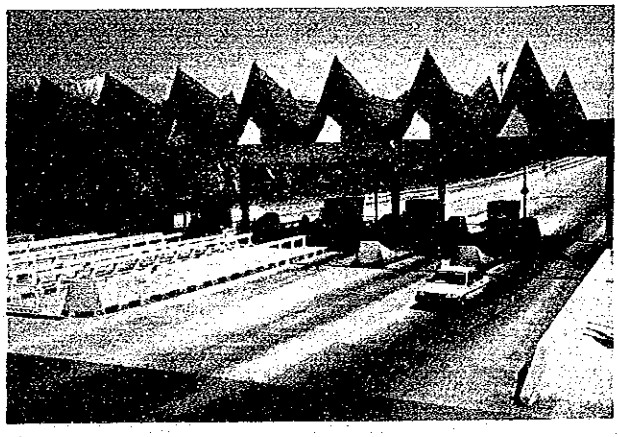
1. A view of the Seremban-Ayer Keroh Section of the North-South Expressway which has a higher design standard than the KL-Seremban Expressway. Notice the paved shoulder and wider lane width.
2. An example of a poorly design parking area. The proximity to a bridge make it difficult to provide a longer taper and hence safety is sacrificed.
3. One of the emergency telephones provided at 2 km apart along the Seremban-Ayer Keroh Section. The telephones are not lighted at night.
4. An overall view of a typical toll gate at Ayer Keroh Interchange.
5. The traffic patrol car belonging to the Concession Company PLUS.
6. Equipment carried in the patrol car. The use of a sedan car limits the number of items that can be carried in the patrol car.
7. A toll gate control panel at one of the toll gate office.





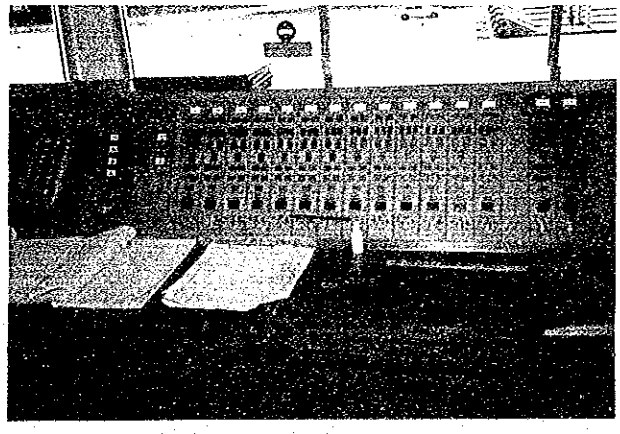


Photo Sheet D

1. Steep cut slopes and overloaded trucks are common features of Karak Highway.
2. Entrance to the one-bore Genting Tunnel at Karak Highway. Poor ventilation has aggravated the problem of dimness in the tunnel.
3. An example of the several at-grade *intersections* along the Senai-Johor Bahru Highway.
4. Another view of the Senai-Johor Bahru Highway that has no access control.
5. The Genting Sempah tunnel maintenance office.
6. Lack of periodic cleaning of tunnel wall and ceiling has resulted in the poor visibility in the tunnel. The dirt coated emergency telephone sign shown here can hardly be seen by passing motorists.
7. Slope slip is a common problem along Karak Highway.

c) Problems on Both Expressway and Toll Highway

i) Adverse weather conditions

Unusual weather conditions obstruct traffic on the expressway and toll highway in the following manner:

* Insufficient sight distance and skid resistance on road surface caused by high density of rainfall and sometimes thunderstorm
* Disaster such as landslide and landslip caused by rainfall
* *Crosswind*

At present, the relationship between rainfall and landslide/landslips cannot be analyzed due to absence of meteorological data at these places as well as unavailability of disaster record.

ii) Shortcoming in Accident Analysis

The accident data on expressways and highways are unfortunately not classified separately even though accident data and analysis has been done in general in Malaysia which in turn illustrates an inadequate information system.

Even though a computerized information system using a new form of accident data sheet which includes accidents on expressways and highways has been introduced from January 1989 by the Royal Malaysian Police but it is still doubtful that it can provide a data base good enough for comprehensive analysis of accident on expressways and highways and thereby enabling the proposal of appropriate plans and countermeasures against accidents on expressways.

iii)Inadequacy in Maintenance

The MHA and PLUS are still in the process of agreeing on a common manual for use by both parties.

2.2 Issues and Necessity for Traffic Control and Management

1) Issues

The following issues on traffic control and management are identified:

a) Insufficient traffic control and management measures at present for constituting a well-coordinated and comprehensive traffic control and management system needed for the efficient operation of expressways and highways,

b) Inadequate provision of safety facilities on the expressways and highways, and the lack of standardization on the design, installation of such devices or facilities as guide signs, lane markings, acceleration and deceleration lanes,

c) Poor road conditions on certain sections of the expressways and highways due to poor design elements and damages caused by overloaded vehicles,

d) High traffic accident rate and vehicle breakdown incidents on the expressways and highways and yet there is an acute lack of traffic accident data and analyses while the present first-aid measures are not sufficient,

e) Insufficient maintenance activities and frequency that have resulted in the less than satisfactory conditions of the expressway, highways and tunnels,

f) Undesirable driving habits of expressway and highway users and their lack of knowledge on safe driving and behavior on expressways,

g) Inadequate data collection and analyses on adverse weather conditions and incidents caused by such phenomena on the expressways and highways.

2) Necessity

As a means to alleviate if not eliminate the various problems and issues identified earlier, the introduction of a comprehensive traffic control and management system on the Malaysian expressways and highways is strongly recommended.

a) Necessity for the Introduction of a Traffic Control and Management System

It is widely recognized that early detection of incident and confirmation of its magnitudes and nature are the basic essentials for the provision of prompt and appropriate first-aid measures in saving human lives on the expressways and highways. Inaccurate information and slow responses to incidents can lead to loss of lives as well as creating heavy traffic congestion on expressway, which in turn generates potential danger in secondary incidents. Moreover, due to the fact that a diversity of persons from different agencies are involved from the point where information on site is gathered, transmitted and appropriate actions are taken, a well coordinated system of traffic management is vital.

Given the fact that traffic volumes are high and increasing rapidly in and around Kuala Lumpur, early detection of traffic congestion and provision of countermeasures can improve traffic mobility and reduce traffic accident. The expressways and highways also pass through areas with concentrated heavy rainfall which can cause landslides that pose potential hazards to drivers. There is a need to provide prompt warnings to drivers on the potential dangers of landslide, strong cross winds, steep up-slope and down-slope as well as slow moving vehicles.

b) Necessity of Organization Set-up and Strengthening Manpower, Mobility and Equipment in Compatibility with the Traffic Control and Management System

The traffic control and management system to be introduced shall be equipped with the following functions on traffic operation:-

i) Communication among centers, maintenance offices, patrol units of the system, agencies involved in traffic operation and roadside traffic control equipment or devices,

ii) Traffic surveillance,

iii) Decision making on countermeasures to be taken when incidents or emergencies occur,

iv) Coordination among the various executing bodies on traffic operation.

Given that many agencies are involved with interlocking responsibilities and functions, it is necessary to establish an organization capable of efficiently manage the system. This organization should also be strengthened in its manpower, mobility and equipment to facilitate system operation and execution of activities in meeting the social needs and demands.

c) Necessity of Establishing A Traffic Engineering Study Section

It is widely understood that full understanding on what has happened, is happening and will happen on expressways and highways is essential for effective traffic management.

This understanding or knowledge can be acquired only through accident and traffic volume analyses and also by such activity as careful examination of drivers behavior and accident rates changes before and after the modification of geometric design and improvements to the traffic control devices are made.

This acquired knowledge will contribute much to the improvement of the planning of improvement works, geometric design and traffic safety measures and devices. Therefore, it is necessary to establish a traffic engineering study section within the organization to deal mainly with:-

i) accident data filing and analyses
ii) traffic volume data filing and analyses
iii)minor improvement design for upgrading traffic safety.

d) Necessity of Enhancing Consciousness of Traffic Safety to Expressway Users

Illegal or improper driving habits would lead to accident, vehicle breakdown and obstruction to smooth flow of traffic. These are problems presently affecting the safety level of the expressways and highways in Malaysia. Thus, it is necessary to enhance traffic safety consciousness among the public in general and expressway users in particular; through:

i) traffic safety campaign on safe expressway driving by the use of public media in close coordination with nation-wide traffic safety campaign initiated by the National Road Safety Council;

ii) wide publicity on traffic safety information by giving leaflets or pamphlets to expressways users in bringing to their awareness of the safety facilities provided along the expressways and highways; guidance to offenders in close coordination with Police when they carry out enforcement on overloaded vehicles, poorly maintained vehicles and over speeding.

3.0 FUTURE TRAFFIC VOLUME AND EXPRESSWAY NETWORK

1) Future Expressway Network and Stage Plans

The expressway network as planned will extend from Bukit Kayu Hitam at the Thai border in the Northern State of Perlis, down along the west coast and running very close to the existing Federal Route 1 to Johor Bharu in the Southern State of Johor. This North-South inter-urban expressway is scheduled to be completed by May 1995.

The sections of the North-South Expressway that have been opened to traffic as of August 1989 are:-

*	Bukit Kayu Hitam-Gurun	(80 km)
*	Changkat Jering-Ipoh	(56 km)
*	Kuala Lumpur-Seremban	(53 km)
*	Seremban-Ayer Keroh	(68 km)
*	Ayer Keroh-Pagoh	(53 km)

These add up to a total of 314 km of expressways in operation by August 1989.

There are also a total of 145 km of toll highways. These are:-

*	Penang Bridge	(14 km)
*	Karak Highway	(68 km)
*	Senai-Johor Bharu Highway	(28 km)
*	Slim River-Tanjung Malim	(20 km)
*	North Klang Straits Bypass	(15 km)

By 1995, the expressway and highway network in Peninsular Malaysia is as shown in Figure 4. The network will consist of the inter-urban North-South Expressway, Karak Highway linking Kuala Lumpur to Bentong and continues as Federal Route 2 to Kuantan on the east coast, New Klang Valley Expressway and Federal Highway; Senai-Johor Bharu Highway in the south and Penang Bridge in the north.

The total length of expressway and toll highways scheduled to be operational by 1995 will be 826 km and 111 km respectively.

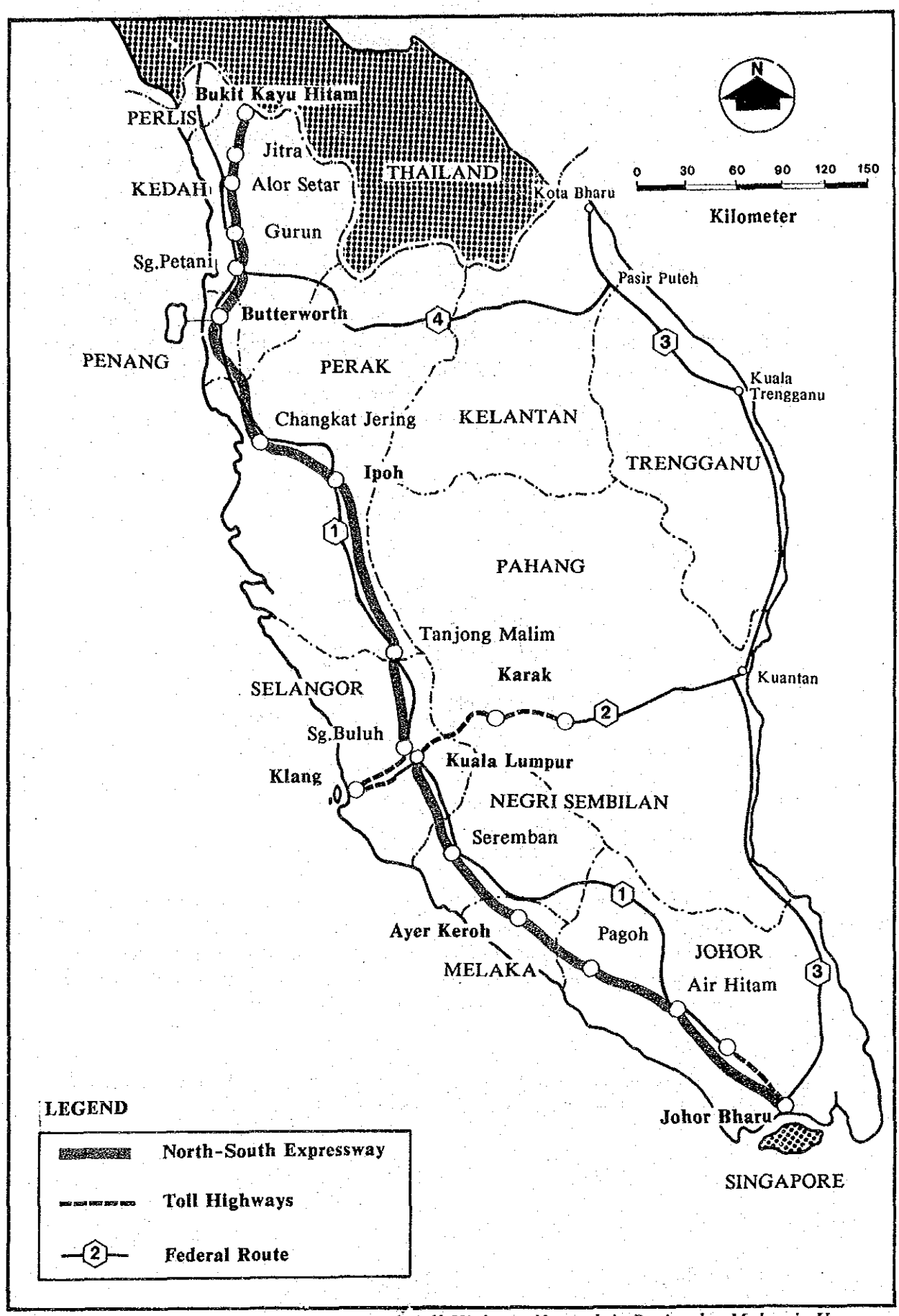


Figure 4: The Future Expressway and Toll Highway Network in Peninsular Malaysia Up To 1995

2) Ranking of Future Traffic Volume

Future traffic volume on the expressway sections represent an important factor for designing appropriate traffic management and control measures. The amount of traffic using a certain expressway section would first help determine the traffic management level that should be adopted to ensure users safety and mobility. The traffic management level in turn would determine the specific types of traffic control devices and maintenance measures required.

A section of the expressway that expects a high future traffic volume would generally require a higher traffic management level. Traffic surveillance by means of vehicle detectors, for example, would be more densely provided. Maintenance work such as inspection, repairs, cleaning would be more frequent so as to maintain the expressway in good condition.

Since the future traffic volume for the expressway sections have been set in the Concession Agreement, it follows that it would be reasonable to adopt these forecasts for the planning of the traffic control and management system in this study. However, toll units were used in the computation of pcu.km in the agreement. For planning purposes, these are duly converted into technical pcu.

In addition, adjustments have also been made to include the motorcycle traffic so as to reflect the total traffic volume on the expressways and highways. The final traffic volume in 1995 and 2005 to be adopted for the design of the traffic control and management system is ranked according to three categories as presented in Table 2.

Table 2: Future Traffic Volume and Estimation V/C Ratios

Expressway Section	Code	(km)	Ranking of Traffic Volume			Volume/Capacity Ratio		
			1988	1995	2005	1988	1995	2005
NORTH-SOUTH EXPRESSWAY								
Bukit Kayu Hitam-Jitra	4A	24.0	1	1	1	0.03	0.04	0.06
Jitra-Alor Setar South	4B	23.0	1	1	1	0.08	0.12	0.21
Alor Setar South-Gurun	4C	33.6	1	1	1	0.10	0.14	0.25
Gurun-Sungai Petani North	5A	16.1	-	1	2	-	0.36	0.70
Sungai Petani North-Sungai Petani South	5B	7.9	-	1	1	-	0.27	0.55
Sungai Petani South-Sungai Dua	5C	22.6	-	1	1	-	0.34	0.66
Sungai Dua-Butterworth	5D	4.2	-	1	1	-	0.18	0.34
Butterworth-Bukit Tengah	6A	10.1	-	1	1	-	0.12	0.20
Bukit Tengah-Taiping	6B	61.6	-	1	1	-	0.25	0.52
Taiping-Changkat Jering	6C	14.9	-	1	1	-	0.32	0.63
Changkat Jering-Ipoh South	7	55.7	1	1	1	0.19	0.31	0.65
Ipoh South-Gopeng	8A	21.5	-	1	2	-	0.46	0.95
Gopeng-Bidor	8B	43.2	-	1	2	-	0.39	0.76
Bidor-Tanjong Malim	9	60.6	-	1	1	-	0.32	0.65
Tanjong Malim-Rawang	10A	43.3	-	1	1	-	0.30	0.59
Rawang-Sungai Buloh	10B	12.4	-	1	3	-	0.67	1.16
Sungai Buloh-Bukit Lanjan	10C	4.2	-	1	2	-	0.63	1.09
Kuala Lumpur-Kajang IC		12.6	3	3	3	1.34	2.21	4.51
Kajang IC-Bangi		6.3	2	3	3	0.99	1.53	2.84
Bangi-Seremban		33.8	2	2	3	0.80	1.11	1.77
Seremban-Simpang Ampat	11B	45.9	1	1	1	0.29	0.39	0.60
Simpang Ampat-Ayer Keroh	11C	21.5	1	1	1	0.19	0.25	0.38
Ayer Keroh-Pagoh	11D	53.0	-	1	1	-	0.22	0.33
Pagoh-Yong Peng South	12A	43.0	-	1	1	-	0.29	0.43
Yong Peng South-Ayer Hitam	12B	19.0	-	1	1	-	0.28	0.55
Ayer Hitam-Simpang Renggam	13A	21.4	-	1	2	-	0.37	0.74
Simpang Renggam-Skudai	13B	45.3	-	1	2	-	0.36	0.77
Skudai-Johor Bharu	14A	13.8	-	1	2	-	0.66	1.12
TOLL EXPRESSWAY AND TOLL HIGHWAYS								
Bukit Raja-Subang (NKVE)	1	16.2	-	2	3	-	0.92	1.50
Subang-Jalan Duta (NKVE)	2	20.8	-	3	3	-	1.66	2.48
Penang Bridge		14.0	1	2	3	0.57	0.75	1.22
Karak Highway		68.0	1	1	2	1.03	1.43	2.27
Senai-Johor Bharu Highway	14E	28.0	2	1	2	0.66	0.46	0.68
N.K.S.Bypass-Shah Alam (FR2)	3A	6.0	2	2	3	0.95	0.60	0.89
Shah Alam-Subang (FR2)	3B	9.0	3	3	3	2.58	2.02	2.56

Note:
* Ranking of Future Traffic Volume
  1 : <30,000 veh/day
  2 : 30,000 - 50,000 veh/day
  3 : >50,000 veh/day

* Karak Highway is a 2-lane highway
* Federal Route 2 is a 6-lane highway by 1995
* All others are 4-lane expressway and highways up to 2005

4.0 PROPOSED TRAFFIC CONTROL AND MANAGEMENT MASTER PLAN

4.1 Organization Set-up and its Role in Traffic Management

There are currently three bodies which are directly involved in traffic management, that is Malaysian Highway Authority (MHA), PLUS and police, while the local police, fire brigade, hospital, and towing company are indirectly involved as their services are requested when needs arise.

1) Main Tasks and Responsibilities of Management Offices

To facilitate efficient traffic management on the expressways and toll highways, an organization with a three-tier hierarchial setup, comprising of a headquarters, several regional offices and many more maintenance offices, each with their respective roles and responsibilities as well as coordination among them are essential.

The main tasks involved in traffic management can be divided into five items, namely:

a) Planning and programming
b) Traffic engineering
c) Traffic operation
d) Maintenance
e) Coordination with related agencies and public relation

The headquarters is responsible for planning, development and formulation of standards regarding traffic engineering. In addition, it is entrusted to draw up policy, future expressway development plans, work contracts, financial plan for new constructions or improvement works and oversees all works contracted to private companies.

The regional office is responsible for managing the operation and activities of all maintenance and toll offices within its jurisdiction. It is also responsible for planning of maintenance and improvement works and conducting traffic engineering studies for enhancing the efficiency and quality of traffic operation and maintenance. The regional office will also manage the traffic control and management center to facilitate traffic operation.

The maintenance office is mainly devoted to carrying out field activities such as patrolling, maintenance works, first-aid activities, law enforcement and accident investigation.

The proposed main tasks and responsibilities of traffic control and management system and its management offices is shown in Table 3.

Table 3: Main Tasks of Traffic Control and Management System and Its Responsible Office

Main Task	Headquarters	Regional Office	Maintenance Office
1. Planning and Programming	Planning	Basic Design	
2. Traffic Engineering and Safety	Development, Standard and Planning	Survey and Data Processing	
3. Traffic Operation	Policy and Planning	Management	Execution
4. Maintenance	Planning and Consultation	Supervision	Execution
5. Coordination and Public Relation	National Level	Local Level	

Under the Concession Agreement, MHA has an important role to play in ensuring that the five tasks of traffic management listed in the table above are effectively carried out. For the tasks of planning, traffic engineering and inter-agency coordination, MHA has a greater role than the tasks of maintenance and traffic operation which will be largely undertaken by PLUS.

The detailed responsibility of MHA and private company for the five main tasks is shown in Table 4.

Table 4: Details of Responsibility of MHA and PLUS

Main tasks of Traffic Control and Management System		MHA	PLUS
1. Planning and Programming	a. Planning	o	
	b. Road construction, planning, design and maintenance work	o	o design, execution
	c. Location setting and basic design of interchange, bus stop, service and parking areas	o	o design
	d. Implementation plan of traffic control and management system	o	o
	e. Administration and redemption survey and planning	o	o
	f. Checking and approval of above-mentioned tasks	o	
2. Traffic Engineering and Traffic Safety	a. Setting of standards and management level	o	
	b. Road and traffic engineering development and research	o	o
	c. Future traffic volume forecasting	o	
	d. Execution of traffic survey	o	o
	e. Statistical data processing	o	o
	f. Checking and approval of above-mentioned tasks	o	
3. Traffic Operation	a. Basic planning	o	o
	b. Traffic operation		o
	c. Checking and approval of above-mentioned tasks	o	
4. Maintenance	a. Setting of standard, supervision and consultation	o	
	b. Maintenance management		o
5. Coordination and public relation	a. Coordination of relevant agencies	o	o
	b. Response activity	o	o

2) Proposed Management Office Location and Their Coverage

To facilitate effective traffic control and management on the North-South Expressway, it is desirable to have the system divided into three (3) divisions as below:

a) Northern Region

Route Coverage : N-S Expressway - Bukit Kayu Hitam to Rawang
Distance : 442 km
Regional Office: To be located near Ipoh IC

b) Central Region

Route Coverage : N-S Expressway-Rawang to Bukit Lanjan (17 km)
New Klang Valley Expressway (37 km)
Federal Route 2 (Berkeley to Subang - 15 km)

Distance : 69 km
Regional Office: To be located near Subang Airport

c) Southern Region

Route Coverage : N-S Expressway-
Sungei Besi to Kota Tinggi (316km)
Senai-Johor Bharu Highway (28 km)

Distance : 344 km
Regional Office: To be located near Ayer Keroh

The location of the regional offices are arrived at considering the ease of personnel commuting to the office and the maintenance offices under supervision, and of stage construction of the system.

Maintenance offices are usually located near or at interchanges because of the need for easy access to the expressway. For the North-South Expressway, a coverage of 70 km to 90 km is considered to be appropriate as the expressway passes through relatively gentle terrain.

MHA still manages Karak Highway and Penang Bridge. MHA shall therefore retain its two regional offices at Ipoh and Ayer Keroh and its maintenance offices at Penang and Genting. The proposed management office locations is illustrated in Figure 5.

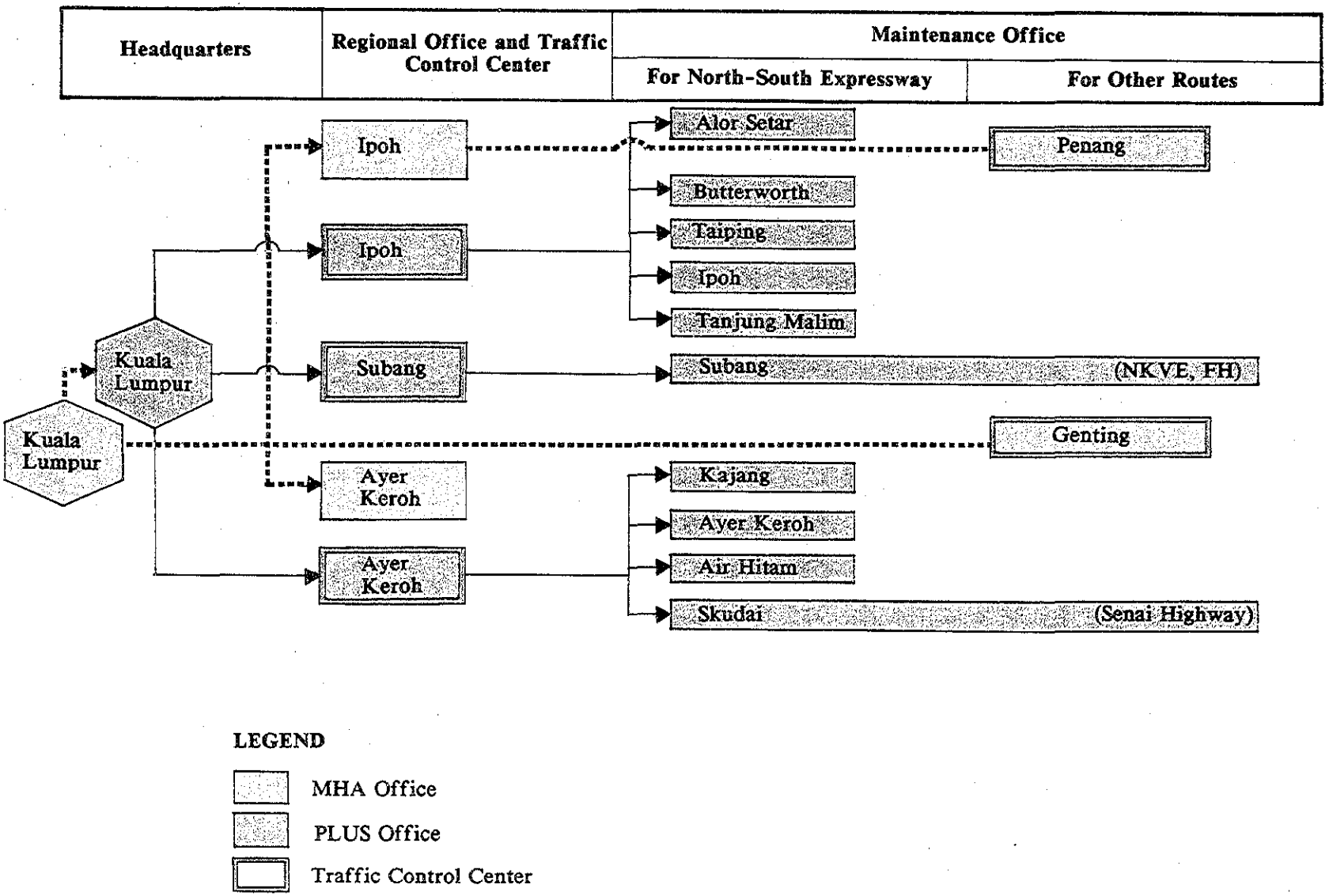


Figure 5: Management Office Locations

3) Traffic Control Center

a) Tasks and Functions

Traffic control centers are located in the regional offices along the North-South Expressway. It is equipped with various central equipment for gathering information on traffic and road conditions, conveyance of such information to drivers, traffic management during any non-recurrent incidents.

Traffic control centers for Penang Bridge and Karak Highway under the management of MHA are provided in the maintenance offices as their traffic operation are independent from that of North-South Expressway.

b) Information Flow at the Center

i) Traffic Control Center at PLUS's Regional Offices

Each of the traffic control center at the regional offices along the North-South Expressway, New Klang Valley Expressway and Federal Highway is to be staffed by PLUS. However, since it is under the jurisdiction of the regional office, the head of the control center is required to obtain consensus/ instructions and report to MHA's regional director as well as PLUS's regional manager.

A police traffic control officer will also be stationed at the traffic control center and through the MHA's regional director or the head of control center, the cooperation of the police, particularly for matters involving law enforcement, accidents, emergencies will be sought. Figure 6 shows the flow of information as to be carried out in a traffic control center.

ii) Traffic Control Center at MHA's Maintenance Office

The traffic control center at Penang Bridge and Karak Highway are fully staffed by MHA's personnel. As shown in Figure 7, cooperation from the police is obtained by consultation via the head of the maintenance office or head of traffic control center.

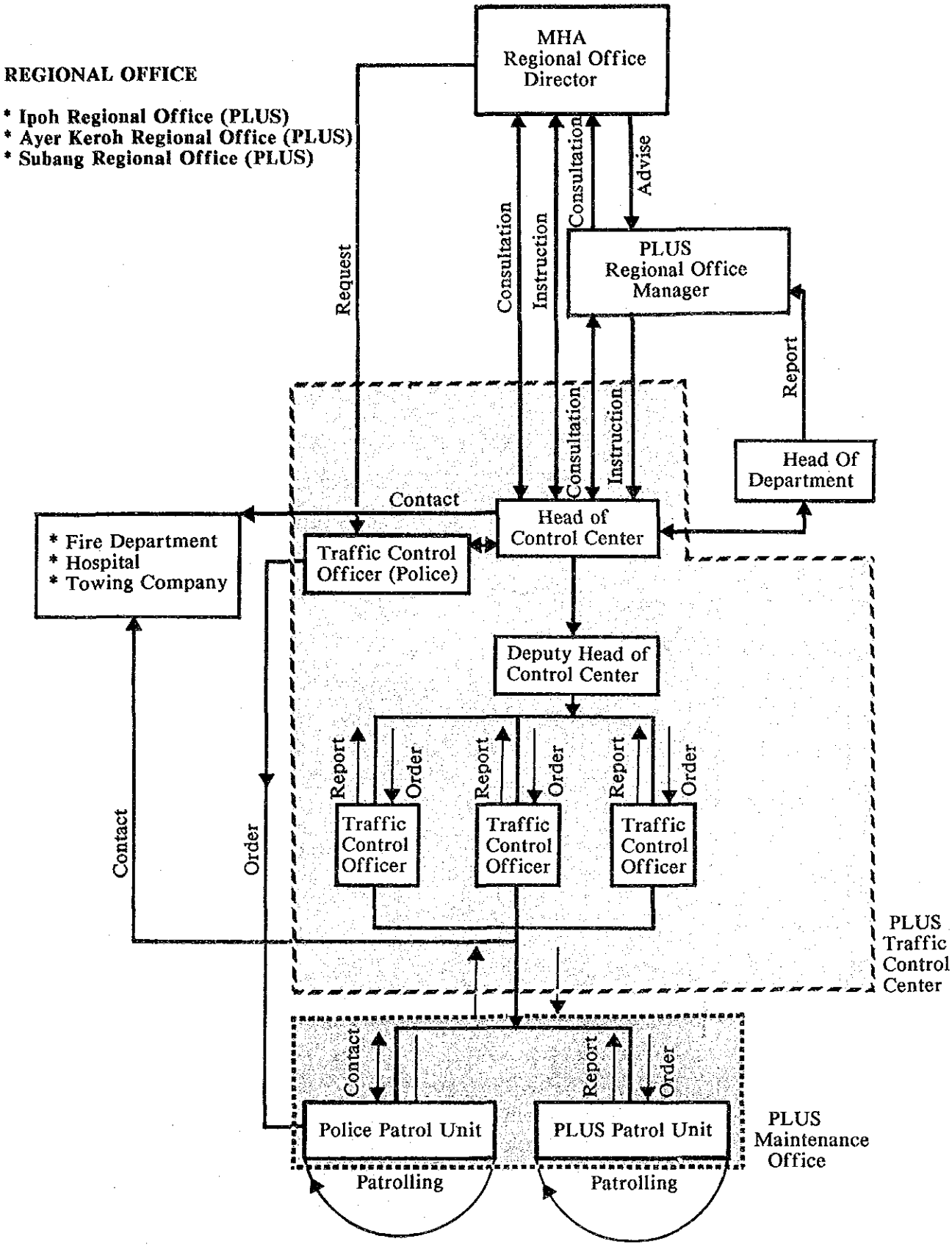


Figure 6: Personnel Interaction at the Traffic Control Center at PLUS Regional Office

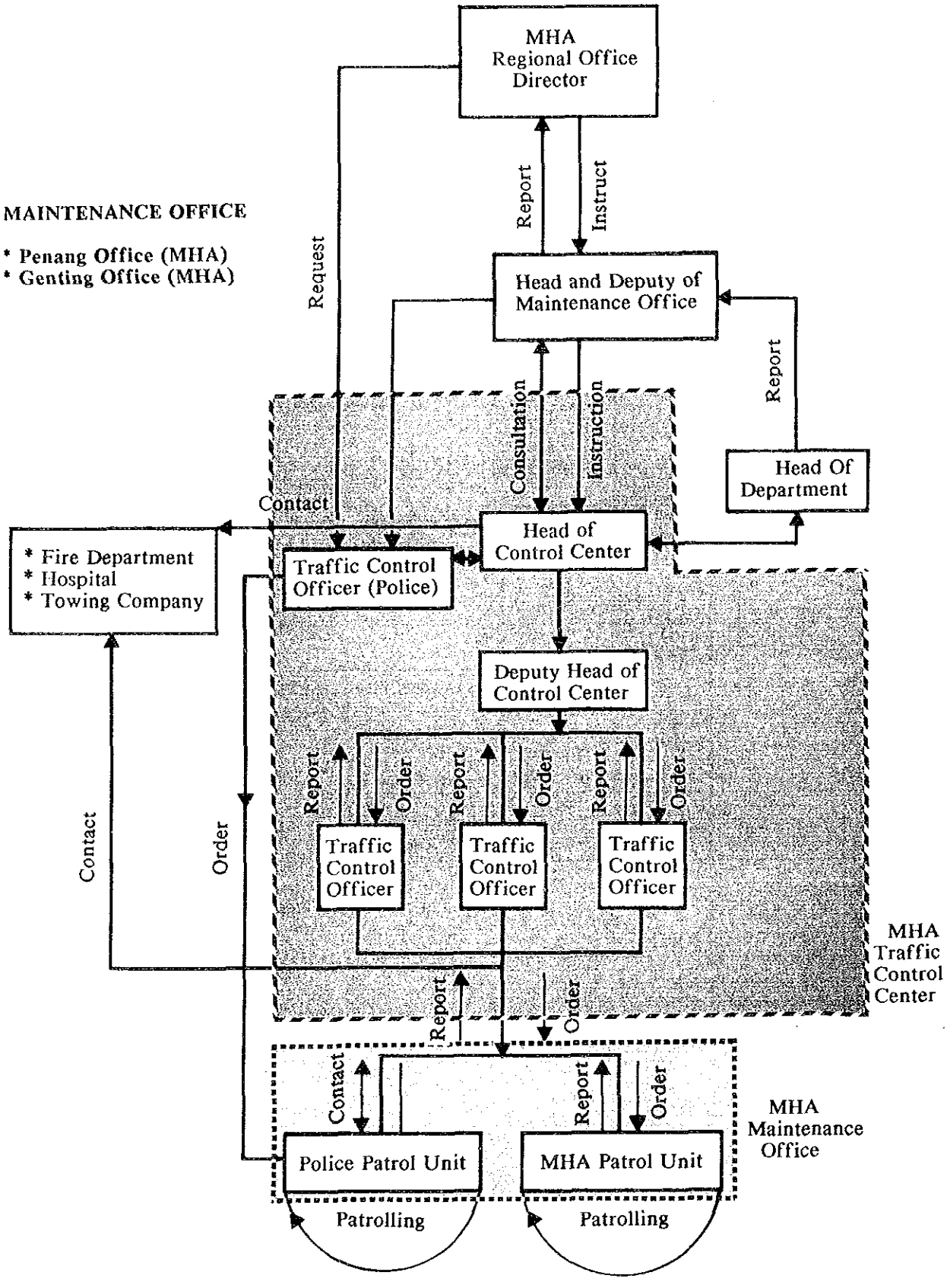


Figure 7: Personnel Interaction at the Traffic Control Center at MHA's Maintenance Office

4.2 Traffic Management Standard

1) Setting of Traffic Management Level

Three levels of traffic management standards are defined here to meet the different requirements of different type and section of study roads.

Traffic Management Level 1

Level 1 is a base of traffic control and management system. Basic information collection, information processing, information dissemination, and traffic control equipment are installed and frame of incident detection and disposal organization is set up at Level 1.

For the North-South Expressway at the present conditions, this traffic management Level 1 may be applied to all sections except the section near to Kuala Lumpur (Kuala Lumpur to Kajang section).

Traffic Management Level 2

At Level 2, equipment installed at Level 1 will be reinforced or supplemented by adding more equipment at increased location, and activity and coordination of the agencies involved in the incident detection and disposal organization will be strengthened.

Traffic Management Level 3

With further growth in traffic demand, increased dependence on expressway and highway system, and social demands or awareness for traffic safety, convenience and comfort; additional and new types of traffic surveillance and information dissemination facilities will be installed and service level will be upgraded at Level 3. Response time to an incident will be improved and various means of information conveyance are provided to cope with versatile requirements of road users.

The proposed traffic management levels as described above are further illustrated in Table 5.

Table 5: Traffic Management Level and Equipment

Level	Objectives	Facility/Equipment	Sections Applied
Level 1	1. Provide road users with means of communication for incident reporting or assistance 2. Provide road users with elementary road and traffic information 3. Establish communication network among related agencies and facilities	Emergency Telephone Exclusive Telephone Wireless System Vehicle Detector Weather Observatory Equipment Changeable Message Sign Changeable Speed Limit Sign	* Applicable to sections having free-flow traffic with a daily traffic volume of below 30,000 veh/day for a 4-lane section.
Level 2	In addition to 1 through 3 above:- 4. Upgrade the traffic flow monitoring function: 5. Upgrade the information dissemination function to road users	In addition to the facilities and equipment above:- CCTV System Radio Broadcasting	* Applicable to sections having more than 30,000-50,000 veh/day(4-lane)
Level 3	In addition to 1 through 5 above:- 6. Strengthen functions of traffic surveillance, incident detection and information dissemination.	In addition to the facilities and equipment at Levels 1 and 2 above:- Highway Radio	* Applicable to sections having more than 50,000 veh/day (4-lane)

Note: It should be emphasized here that the daily traffic volume of 30,000 veh/day or 50,000 veh/day is not absolute as factors such as road condition, weather condition, etc. may warrant its changes.

2) Road Classification, Target Year and Traffic Management Level

a) Road Classification

MHA has recently adopted the classification of expressways and highways into the following functional categories:-

Category	Routes/Sections
i) Motorway	.. North-South Expressway (except Bukit Kayu Hitam-Jitra Section)
	.. New Klang Valley Expressway
	.. Penang Bridge
ii) Expressway	.. Bukit Kayu Hitam-Jitra Section on the North-South Expressway
	.. Federal Highway (Subang Airport-Berkeley Roundabout)
	.. Senai-Johor Bharu Highway
iii)Highway	.. Karak Highway

b) Target Year

In line with the construction program (Table 6), implementation of the traffic management system is divided into three stages; those measures to be taken for the existing routes (short term plan), those to be implemented by 1995 (medium term plan), and those to be adopted by 2005 (long term plan). Short term plan is prepared to alleviate the problems and issues on the existing route and can be implemented immediately. Medium term plan applies to the route to be constructed and coincides with the construction program. Long term plan will be implemented after 1995 up to 2005 in conjunction with the increase in traffic demand and change in expressway environments.

Table 6: Construction Program

Route	Section	Completion
N-S Expressway	Bukit Kayu Hitem-Gurun	Open
	Gurun-Butterworth	1992
	Butterworth-Changkat Jering	1995
	Changkat Jering-Ipoh	Open
	Ipoh-Tanjung Malim	1995
	Tanjung Malim-Kuala Lumpur	1992
	Kuala Lumpur-Ayer Keroh	Open
	Ayer Keroh-Pagoh	Open
	Pagoh-Ayer Hitam	1992
	Ayer Hitam-Johor Bharu	1994
New Klang Valley Expressway		1992
Penang Bridge		Open
Kuala Lumpur-Karak Highway		Open
Federal Highway	Subang Airport-Berkeley Roundabout	1992
Senai-Johor Bharu Highway		Open

c) Traffic Management Level for Each Section

The staged implementation for each section of the motorway, expressway and highway is described below.

In Stage 1, Level 1 standards are applied to all sections of North-South Expressway already opened to traffic. Penang Bridge is already equipped with the roadside facilities of Level 1 but operation organization including rescue and assistance service must be established. Level 2 standards are applied to only Karak Highway in which traffic demand has already exceeded the capacity.

In Stage 2, newly opened sections of North-South Expressway will be provided with Level 1 facilities and sections between Kuala Lumpur and Seremban will be upgraded to Level 2. Level 2 standards will be applied to New Klang Valley Expressway when it is opened in 1992 as the traffic forecast warrants it. Penang Bridge and Karak Highway will be upgraded to Level 2 and Level 3 respectively.

In Stage 3, Kuala Lumpur-Seremban section will be upgraded to Level 3 together with New Klang Valley Expressway and Penang Bridge while some sections of North-South Expressway, namely Gurun-Changkat Jering, Ipoh-Kuala Lumpur and Ayer Hitam-Johor Bharu are to be upgraded to Level 2. Figure 8 depicts the traffic management level by each expressway section in year 2005.

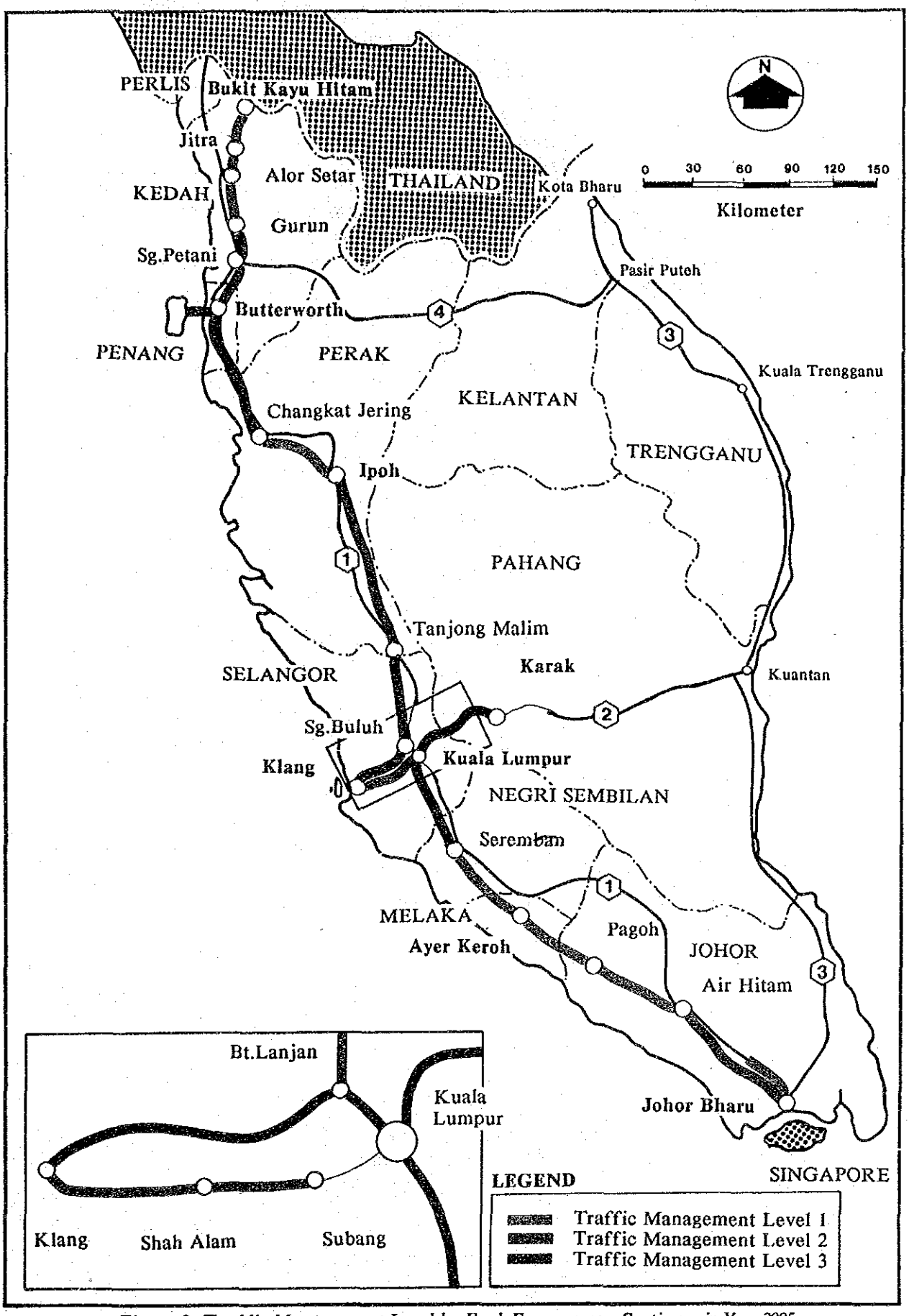


Figure 8: Traffic Management Level by Each Expressway Section in Year 2005

3) Route Numbering System

The expressway route numbering assigned should bear some relations to those already in use for the Federal Routes, so as to provide easier travelling to the motorists. In order to distinguish from Federal route number, expressway logo and Alphabet E will precede the route number for expressway, for example, E1 Green color is proposed to be used for the background of the route number markers.

The proposed route numbering for the study routes are as shown in Figure 9.

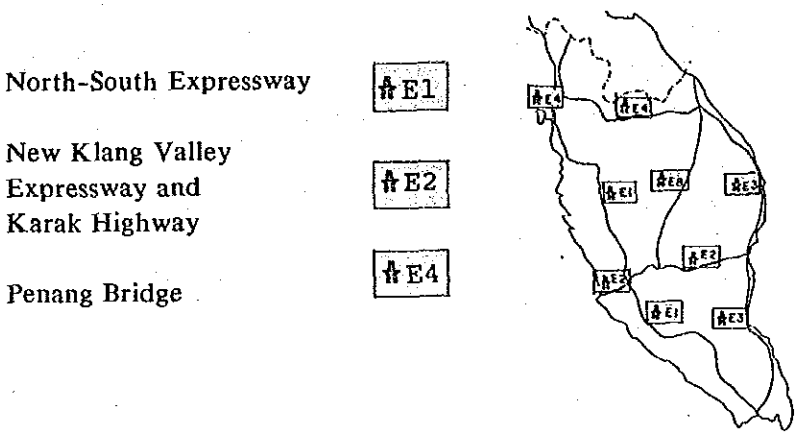


Figure 9: Basic Concept of Toll Expressway Numbering System

In addition, a branch route from main route will be numbered based on the main route numbers, for example, as shown in Figure 10, branch route number consists of main route number and the branch number.

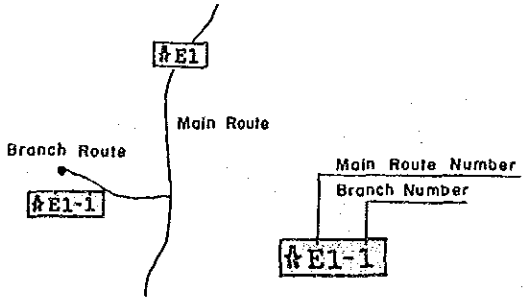


Figure 10: Branch Route Numbering System

4.3 Proposed Traffic Control and Management System

1) Outline of Traffic Control and Management System

In order to manage an expressway efficiently and in an organized manner, a traffic control and management system must be established. The system has four major functions, namely, information collection, information processing and decision making, information dissemination, and execution and enforcement of the decision. Figure 11 depicts the concept of traffic control and management system.

2) Traffic Control Center and Sub-center

Traffic control center is established at regional office as a core of the traffic control and management system. It accommodates a computer system and other associated equipment as well as staff for operation of the system and planning of countermeasures against incidents.

Sub-center is installed at each maintenance office to gather and distribute data for road side equipment, to monitor certain information for prompt execution of countermeasures against incident and to back up the functions of the control center to some extent in case of communication interruption between sub-center and center.

As shown in Figure 12, five traffic control centers and nine sub-centers are proposed for the traffic control and management system. Most of these control centers and sub-centers are established in Stage 2 when the entire stretch of the North-South Expressway will be opened to traffic.

3) Installation Standards

A traffic control and management system consists of various equipment on roadside and at various locations within the expressway management organization as well as a communication network.

These equipment are installed differently on motorway, expressway or highway so as to reflect the traffic management level of each road classification. Table 7 illustrates the general guideline of installation standards for various equipment for motorway, expressway and Karak Highway at each level.

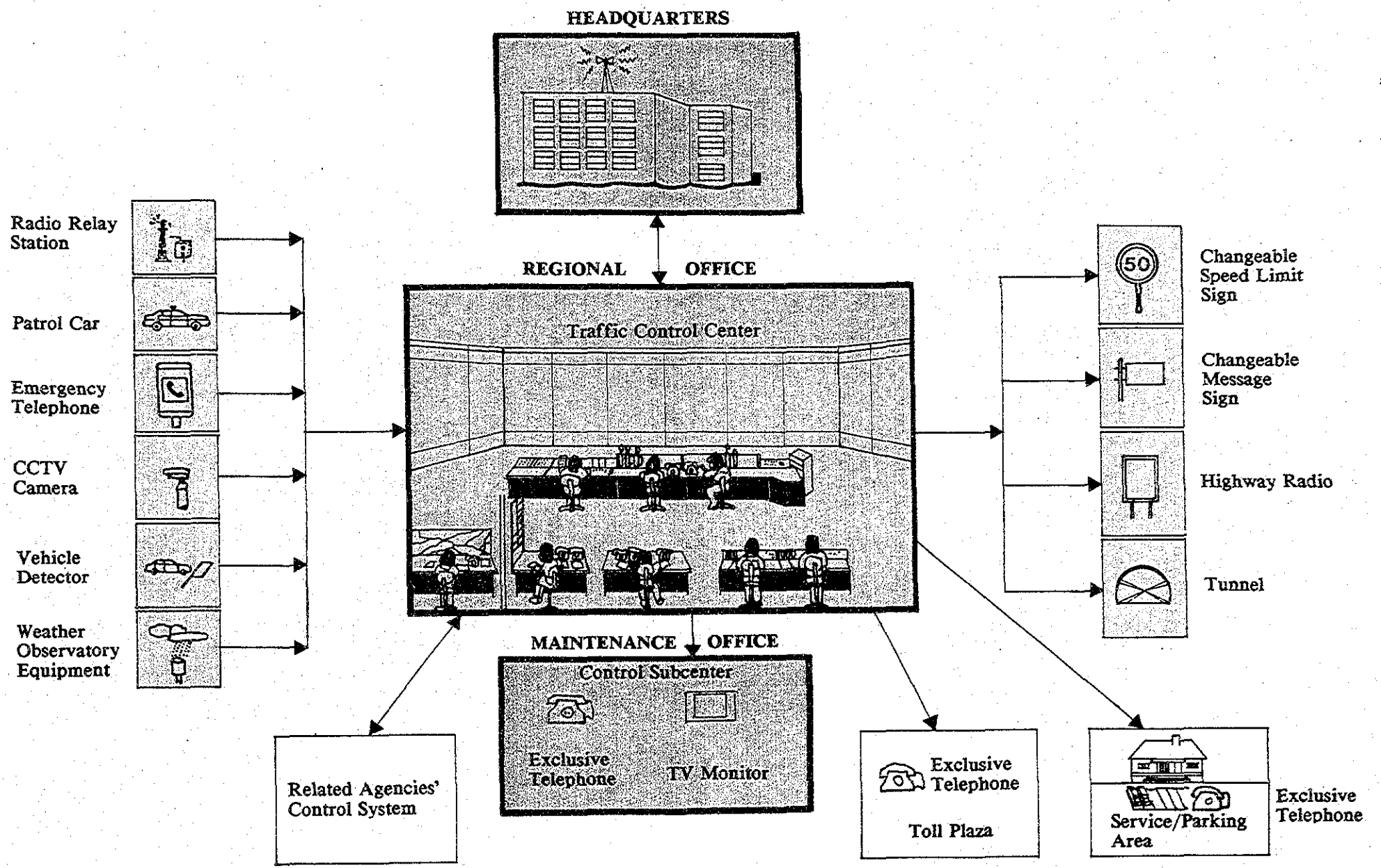


Figure 11: Concept of Traffic Control and Management System

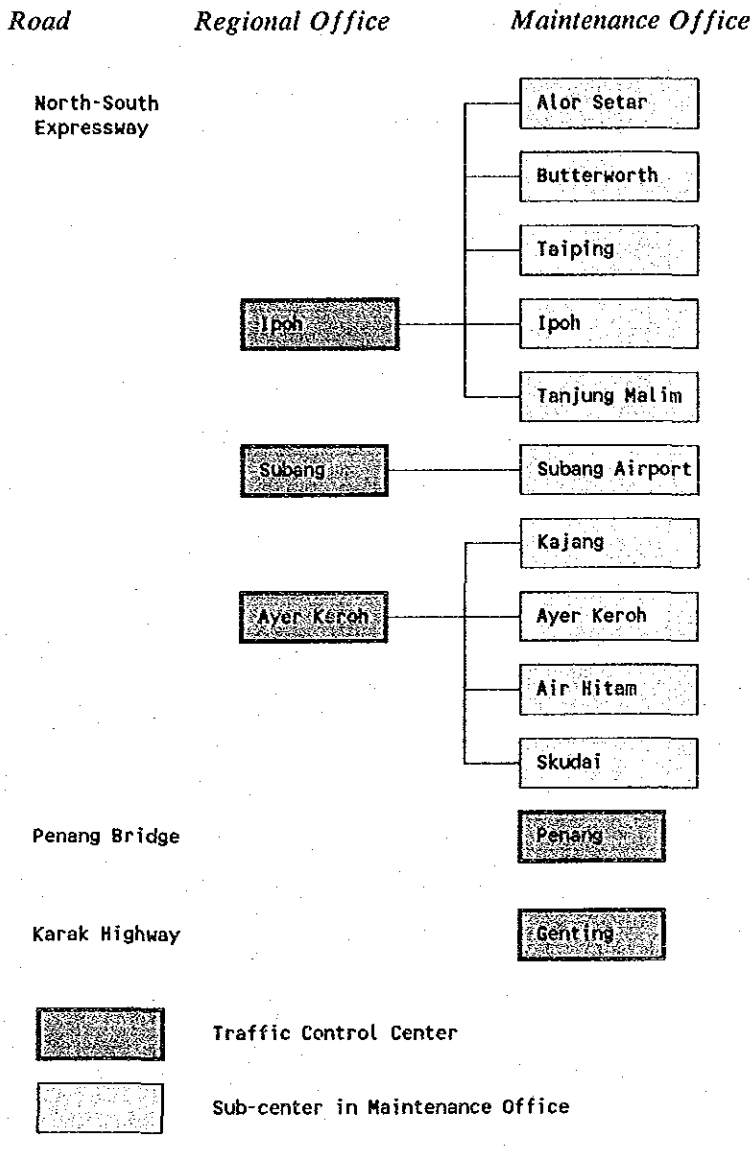


Figure 12: Location of Control Center and Sub-center

Table 7: Installation Standards

Level	Objective/Function	Facilities	Installation Locations		
			Motorway	Expressway	Karak Highway
1	1. Provide road users with means to report incidents 2. Provide road users with elementary road and traffic information 3. Establish communication network among related agencies and facilities	Emergency Telephone	*1km interval on both sides	None	*1km interval on one side
		Exclusive Telephone, Wireless for Patrol Car	Exclusive telecommunication circuit between center and stations; wireless communication between patrol car with stations and center		
		Vehicle Detector	*1 location between major cities	*1 location between major cities	
		Weather Observatory Equipment	*One representative location in high rainfall areas		*One location in the disaster prone areas
		Changeable Message Sign	*Toll booth *Tunnel entrance *Upstream of off-ramp located in major cities	*Toll booth	*Toll booth *Tunnel entrance
		Changeable Speed Limit Sign	*High rainfall areas		
2	In addition to 1 through 3 above, 4. Upgrade the traffic flow monitoring function 5. Upgrade the information dissemination function to road users	Vehicle Detector	*1 location between ICs *On and off-ramp of major ICs	*1 location between major ICs	*1 location between toll gate and tunnel
		Changeable Message Sign	*Upstream of off-ramp at major ICs	*Upstream of off-ramp at major ICs	
		CCTV Camera	*Major ICs and toll plaza	*Major ICs and toll plaza	*Incident/accident prone areas
		Radio Broadcasting	*All areas by broadcasting stations with information in respective areas		
3	In addition to 1 through 5 above, 6. Strengthen functions of incident detection, traffic surveillance and information conveyance	Vehicle Detector	*Recurrent congestion areas	*Recurrent congestion areas	*Recurrent congestion areas
		Changeable Message Sign	*Major access roads	*Major access roads	
		CCTV Camera	*Recurrent congestion areas	*Recurrent congestion areas	
		Highway Radio	*Recurrent congestion areas	*Recurrent congestion areas	

In Level 1, the provision of the very basic facilities namely emergency telephones along the route and laying of communication cable network are carried out. In addition to these, basic equipment that provide the element of safety on the highway are also installed. This include vehicle detector on the mainline between major urban centers, weather observatory devices at maintenance offices and changeable speed limit sign located in adverse weather prone areas, and changeable message signs at toll booth, tunnel entrance and upstream of off-ramp at major cities. In principle, all roadside facilities are operated at the maintenance office at this level.

At Level 2, functions of equipment installed at Level 1 are to be enhanced by either increasing the unit of installations or adding new devices. The installation of vehicle detectors, for example, is increased to one for every section between interchanges as well as at on- and off-ramps at major interchanges. With these increased number of detectors, more traffic data including access and egress traffic volume at major interchanges can be accurately compiled. Changeable message signs are also increased and installed upstream of off-ramp at major interchanges. Visual information gathering is made possible by introducing CCTV system at Level 2 and cameras are installed at major interchanges and toll plaza on mainline. Basic information dissemination by means of radio broadcasting is also introduced.

If traffic control and management system is introduced to two or more adjacent sections, a traffic control center must be set up to effect more efficient traffic control and management between maintenance offices.

Level 3 is to achieve a further sophistication from Level 2 where all the necessary data collection devices are installed to gather detail and accurate traffic data, in particular congestion data. Information dissemination function is further expanded by installing changeable message sign at major access roads to the highway and the use of highway radio and information counter at all service areas.

4) Proposed Traffic Control and Management System Plan

Figure 13 illustrates the proposed traffic control and management system plan at their final stage in year 2005.

Five traffic control centers will be set up at Penang, Ipoh, Subang, Genting, and Ayer Keroh to cover the entire stretch of Penang Bridge, North-South Expressway, Karak Highway, New Klang Valley Expressway, Federal Highway, and Senai-Johor Bharu Highway. A total of nine sub-centers will be placed under them. Communication network using optical fiber cable and carrier transmission will be established between these offices and roadside facilities. Various types of roadside equipment are installed as shown in the diagram.

The final proposed traffic control and management system installation plans on the North-South Expressway, New Klang Valley Expressway, Federal Route 2, Senai-Johor Bharu Highway, Penang Bridge and Karak Highway are shown in Figures 14 through 19. All the proposed roadside equipment are shown in the figures with their respective locations as well as by construction staging.

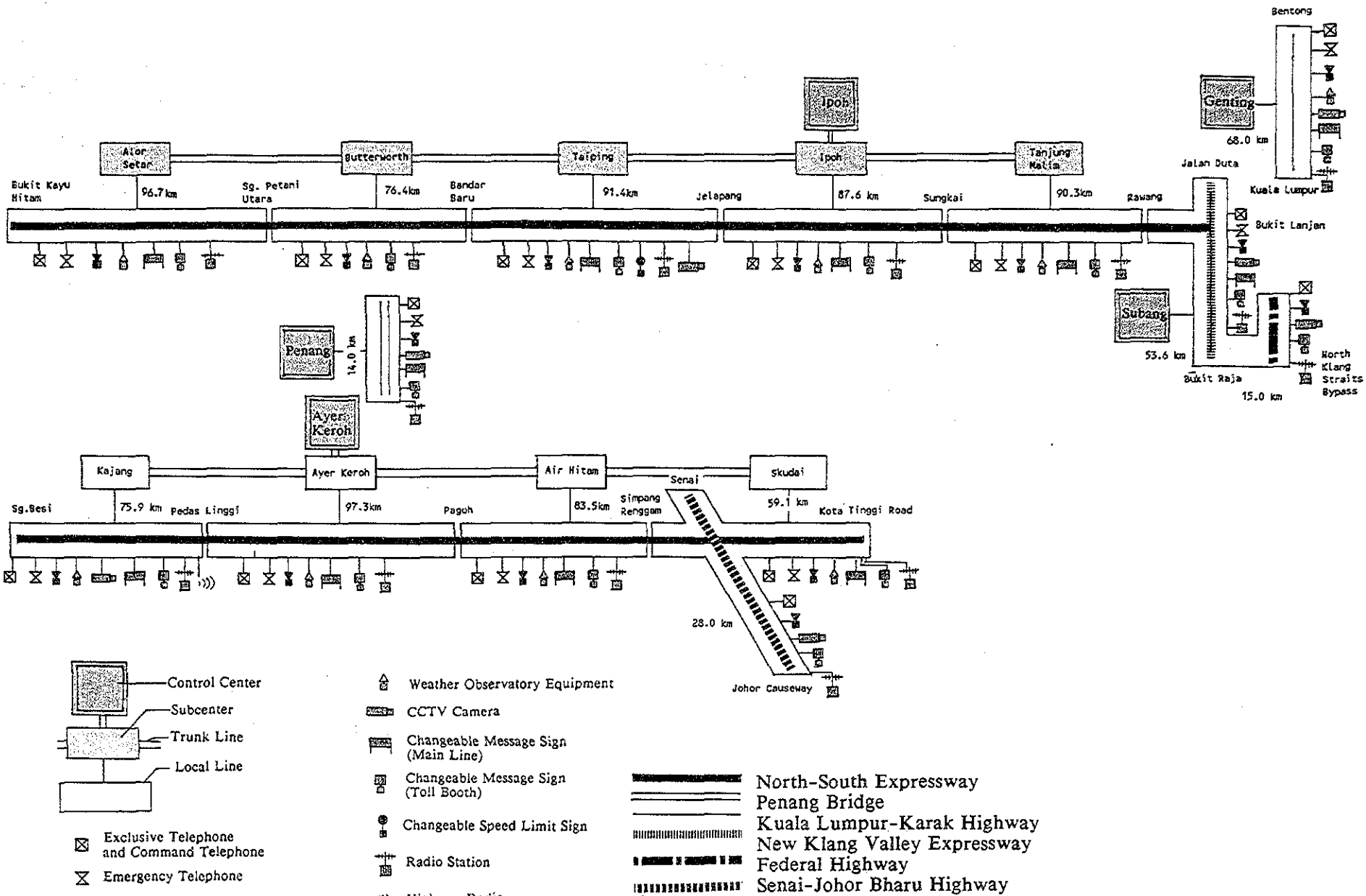


Figure 13: Proposed Traffic Control and Management System Plan

Figure 14: Proposed Traffic Con

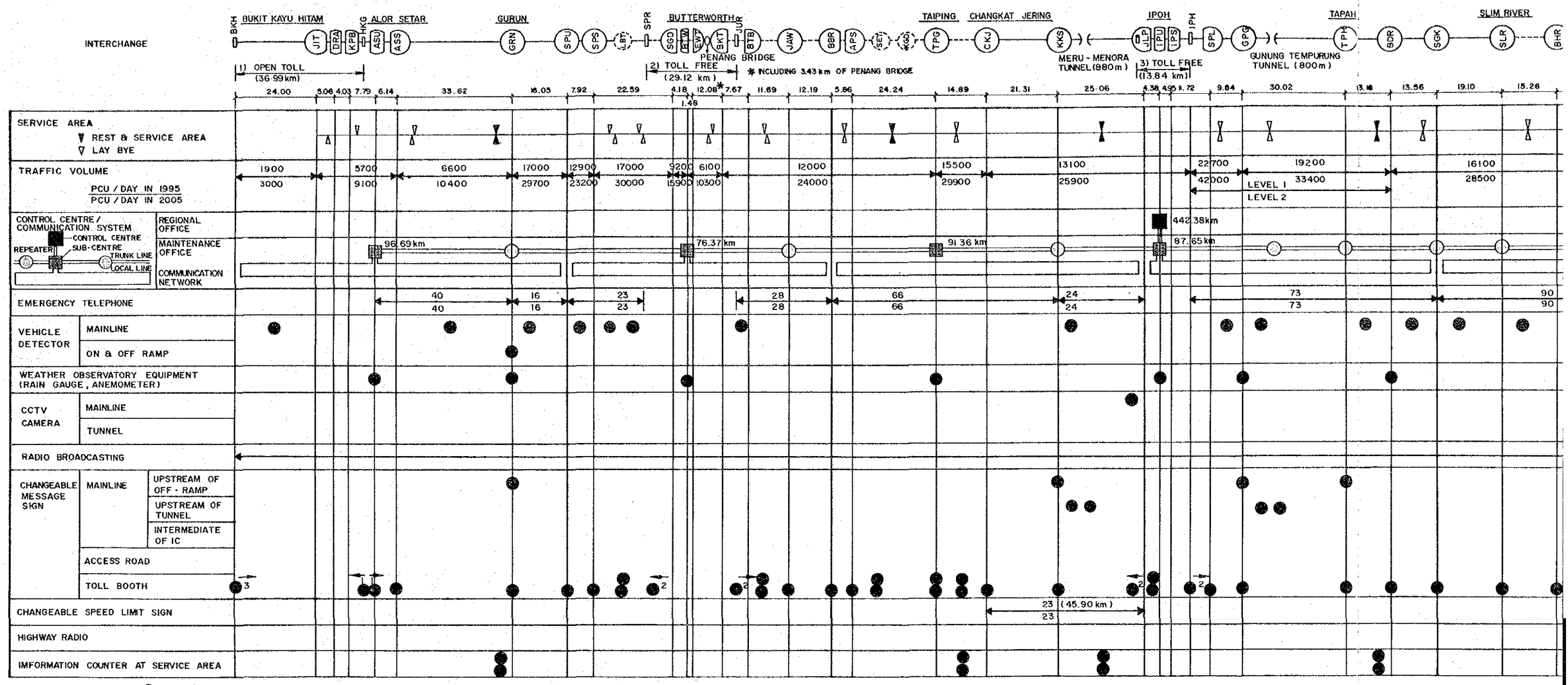
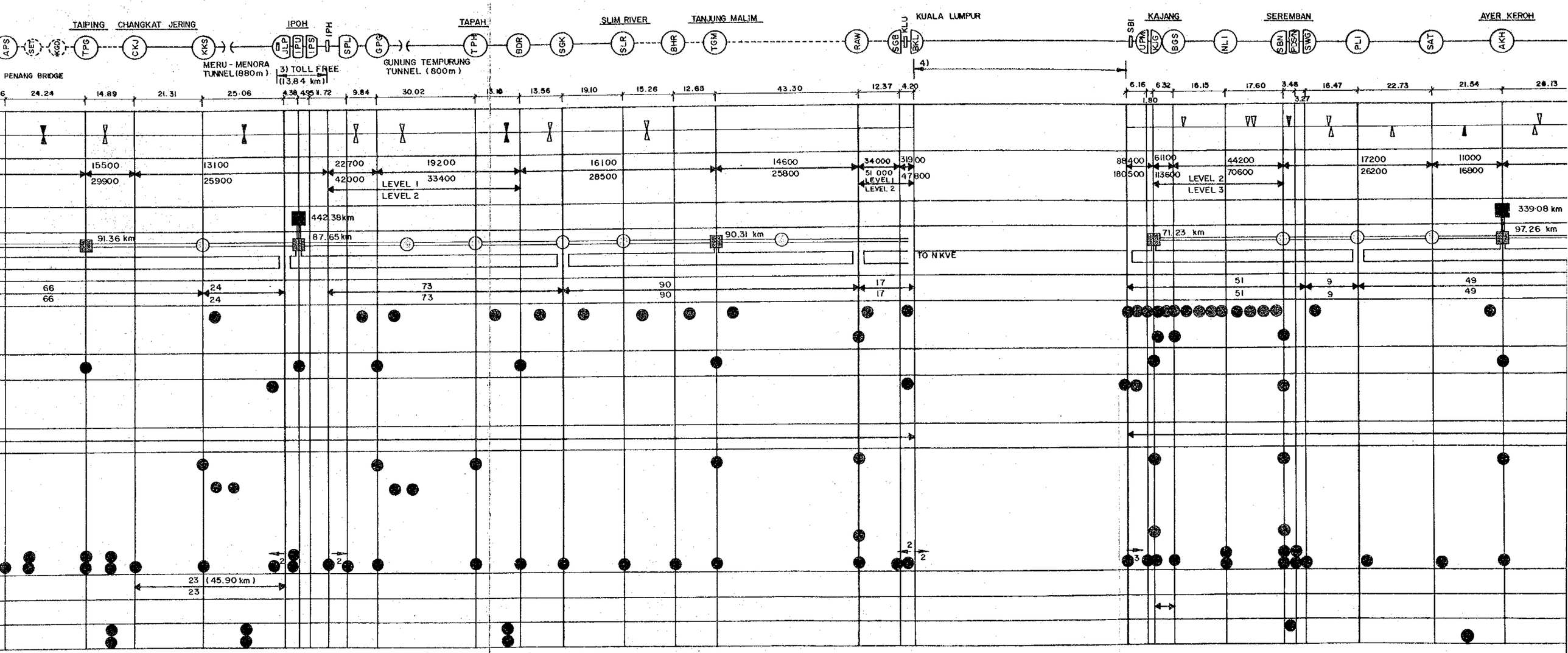


Figure 14: Proposed Traffic Control and Management System Installation Plan for North-South Expressway - 775 km



stem Installation Plan for North-South Expressway - 775 km

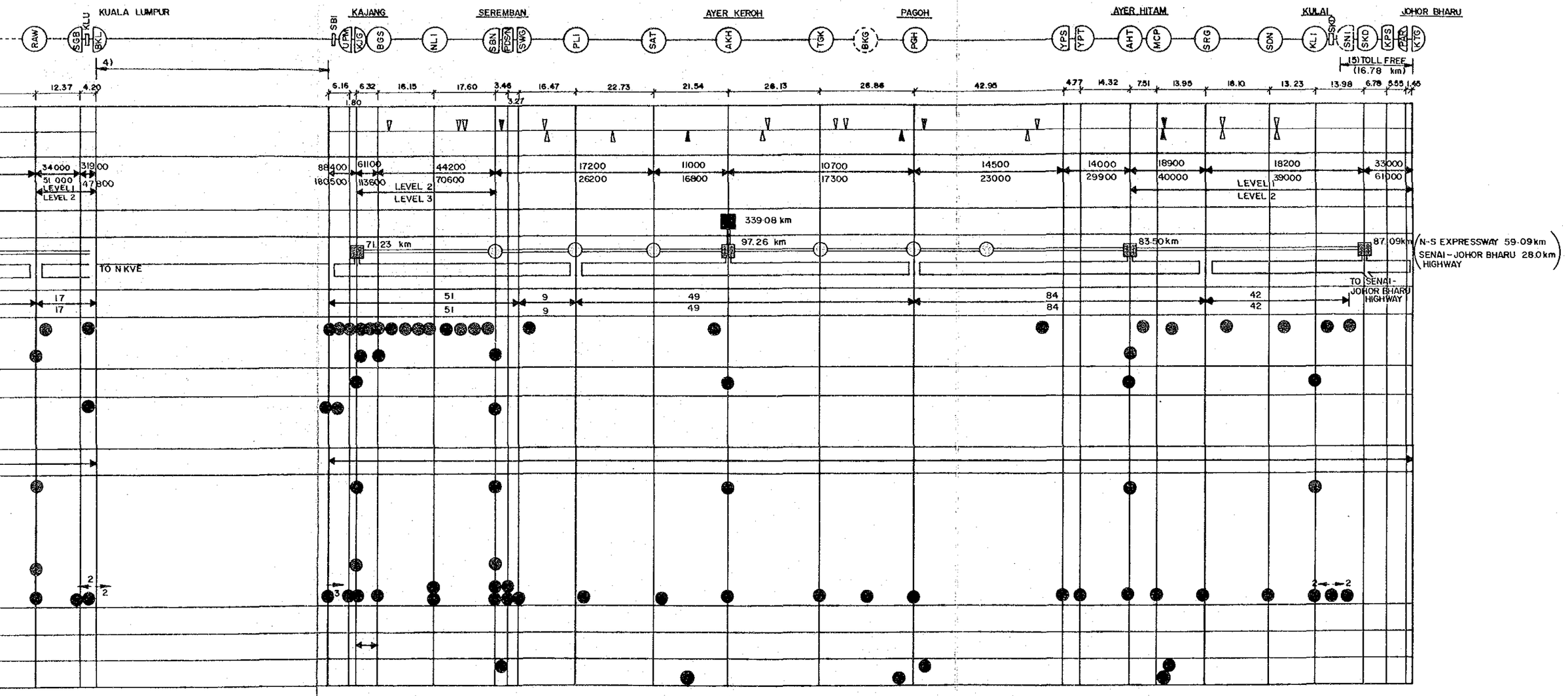


Figure 15: Proposed Traffic Control and Management System Installation Plan for New Klang Valley Expressway - 37.0 km

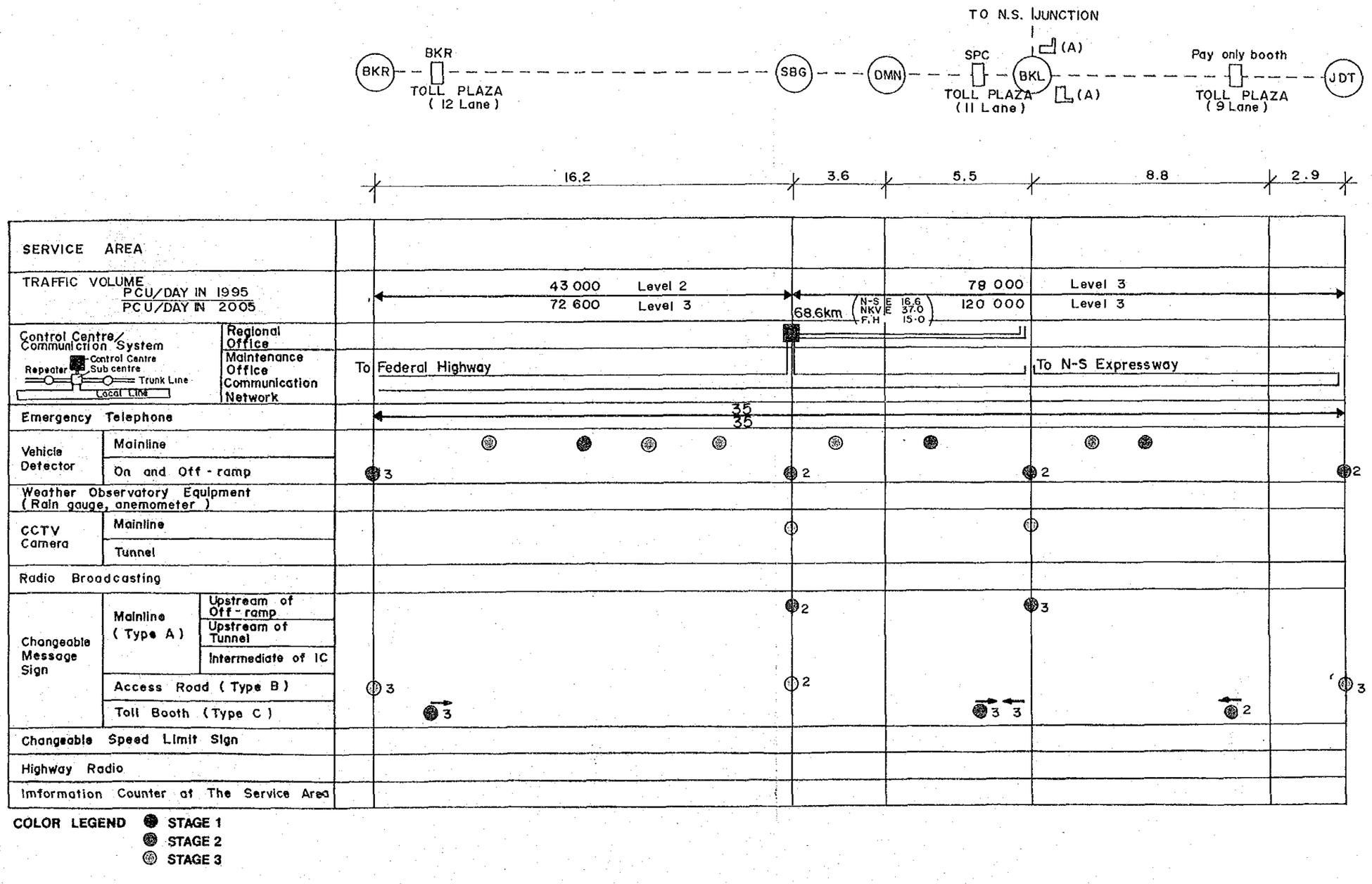
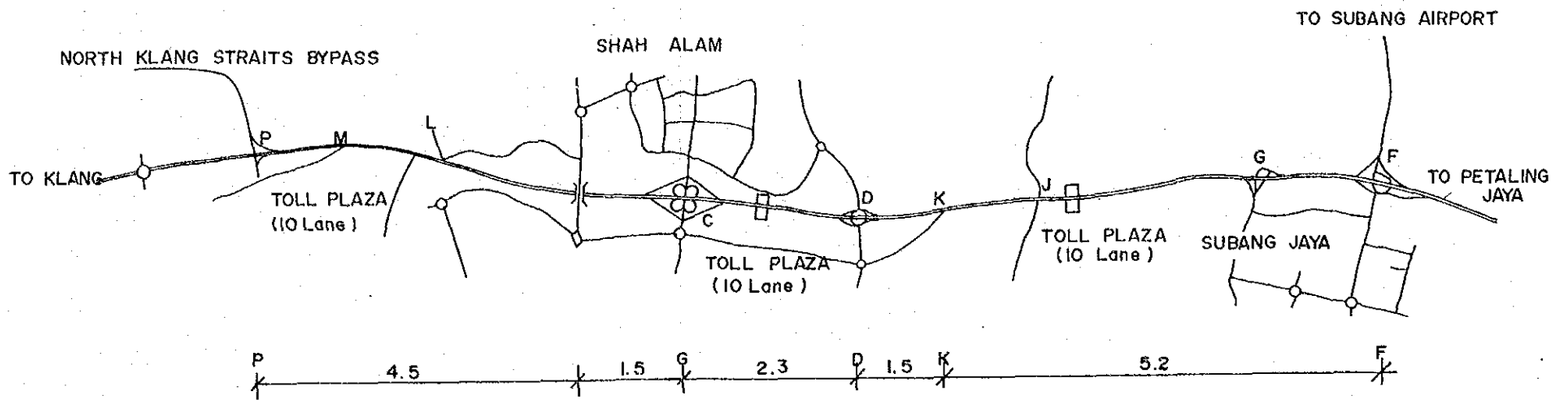


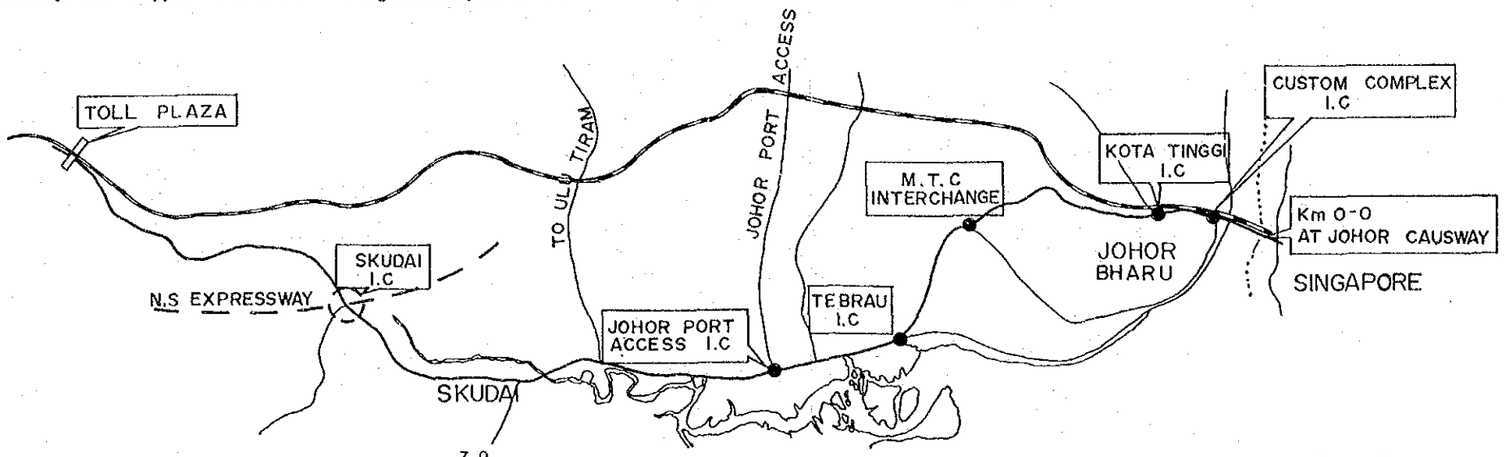
Figure 16: Proposed Traffic Control and Management System Installation Plan for Federal Highway (Berkeley to Subang) - 15.0 km



SERVICE AREA											
TRAFFIC VOLUME PCU/DAY IN 1995 / PCU/DAY IN 2005			46 000 Level 1 / 70 600 Level 2			143 000 Level 1 / 190 000 Level 2					
Control Centre Communication System (Repeater, Control Centre, Sub centre, Trunk Line, Local Line)	Regional Office										
	Maintenance Office Communication Network		To New Klang Valley Expressway								
Emergency Telephone											
Vehicle Detector	Mainline		●	●					●	●	
	On and Off - ramp										
Weather Observatory Equipment (Rain gauge, anemometer)											
CCTV Camera	Mainline										
	Tunnel									●	
Radio Broadcasting											
Changeable Message Sign	Mainline (Type A)	Upstream of Off - ramp									
		Upstream of Tunnel									
		Intermediate of IC									
	Access Road (Type B)										
	Toll Booth (Type C)		◎ 3 3						◎ 3 3		
Changeable Speed Limit Sign											
Highway Radio											
Information Counter at The Service Area											

COLOR LEGEND ● STAGE 1
● STAGE 2
● STAGE 3

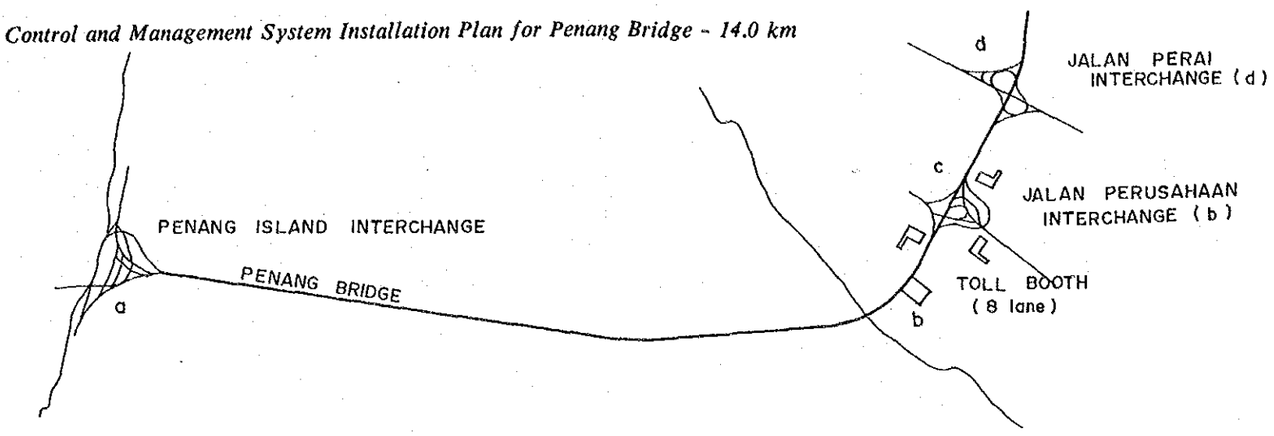
Figure 17: Proposed Traffic Control and Management System Installation Plan for Senai-Johor Bharu Highway - 28.0 km



SERVICE AREA										
TRAFFIC VOLUME PCU/DAY IN 1995 PCU/DAY IN 2005				25200 40700	Level I Level I					
Control Centre/ Communication System Repeater, Control Centre, Sub centre, Trunk Line, Local Line	Regional Office									
	Maintenance Office Communication Network									
Emergency Telephone				To N-S Expressway						
Vehicle Detector	Mainline			●						
	On and Off - ramp									
Weather Observatory Equipment (Rain gauge, anemometer)										
CCTV Camera	Mainline									●
	Tunnel									
Radio Broadcasting										
Changeable Message Sign	Mainline	Upstream of Off - ramp								
		Upstream of Tunnel								
		Intermediate of IC								
	Access Road									
	Toll Booth (Type C)		● 2							● 3
Changeable Speed Limit Sign										
Highway Radio										
Information Counter at The Service Area										

COLOR LEGEND ● STAGE 1
● STAGE 2
● STAGE 3

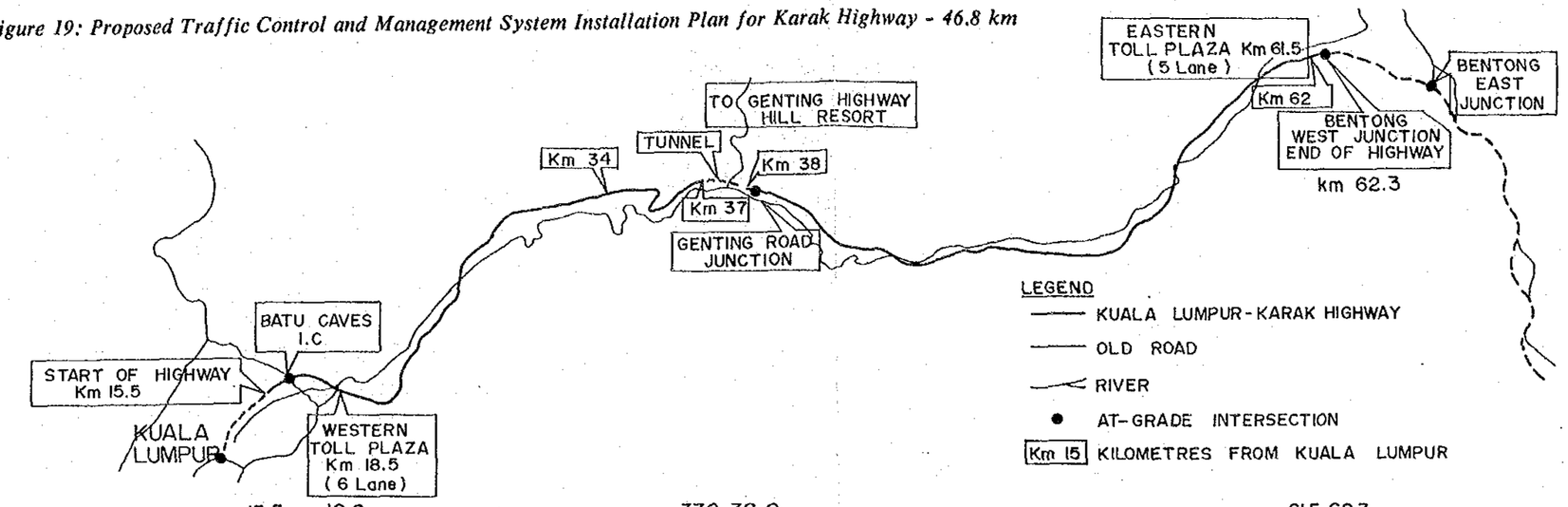
Figure 18: Proposed Traffic Control and Management System Installation Plan for Penang Bridge - 14.0 km



SERVICE AREA			
TRAFFIC VOLUME PCU/DAY IN 1995 / PCU/DAY IN 2005			35900 Level 2 / 58500 Level 3
Control Centre/ Communication System (Repeater, Control Centre, Sub centre, Trunk Line, Local Line)	Regional Office		
	Maintenance Office Communication Network		14 km
Emergency Telephone			(EXISTING)
Vehicle Detector	Mainline		
	On and Off - ramp		2
Weather Observatory Equipment (Rain gauge, anemometer)			
CCTV Camera	Mainline		
	Tunnel		
Radio Broadcasting			
Changeable Message Sign	Mainline (Type A)	Upstream of Off - ramp	x 3
		Upstream of Tunnel	
		Intermediate of IC	
	Access Road (Type B)		2
	Toll Booth (Type C)		4
Changeable Speed Limit Sign			
Highway Radio			
Imformation Counter at The Service Area			

COLOR LEGEND ● STAGE 1
◍ STAGE 2
⊗ STAGE 3

Figure 19: Proposed Traffic Control and Management System Installation Plan for Karak Highway - 46.8 km



			15.5 18.0	37.0 38.0	61.5 62.3
SERVICE AREA					
TRAFFIC VOLUME PCU/DAY IN 1995 / PCU/DAY IN 2005			22 800 / 36 300	Level 3 / Level 3	
Control Centre/ Communication System (Repeater, Control Centre, Sub centre, Trunk Line, Local Line)		Regional Office			
		Maintenance Office		46.8 km	
		Communication Network			
Emergency Telephone			21	4	24
Vehicle Detector	Mainline				
	On and Off - ramp				
Weather Observatory Equipment (Rain gauge, anemometer)					
CCTV Camera	Mainline		2		
	Tunnel			(OXO)	
Radio Broadcasting					
Changeable Message Sign	Mainline (Type A)	Upstream of Off - ramp			
		Upstream of Tunnel			
		Intermediate of IC			
	Access Road (Type B)				
	Toll Booth (Type C)		2		2
Changeable Speed Limit Sign					
Highway Radio					
Information Counter at The Service Area					

COLOR LEGEND
- STAGE 1
- STAGE 2
- STAGE 3

4.4 Proposed Traffic Safety Measures

1) Outline of Traffic Safety Measures

Traffic safety measures cover mainly two basic functions, i.e., preventing accident and minimizing the injuries to road users or damages to properties.

The three factors governing the occurrence of traffic accidents are:

a) Traffic and road environment
b) Road users
c) Vehicles

The component of traffic safety is shown in Figure 20 where the safety measures for accident prevention are illustrated as Nos.1 to Nos.5 while the minimizing damage by accidents is depicted in Nos.6 in the figure.

Accident analysis (Nos.7) is not directly related to these two functions but it is closely related to proposal of appropriate traffic safety plans and measures in the future.

In order to enhance traffic safety on expressway and highways, the level of traffic safety and its determination are described in details in the Main Volume.

2) Improvement Plans for Traffic Safety

a) Improvement Plan of Safe Road Environment

The details of the improvement items for safe road environment inclusive of its implementation priority for expressway and highway are shown in the Main Volume. In addition, a detailed safety improvement plan of Karak Highway is also shown in the Appendix.

b) Accident Analysis and Reporting System

Accident analysis and reporting system is recommended as part of the safety measures as it is essential for research into causes of accident which then enables the proposal of appropriate plans. The improvement items which should be implemented immediately are illustrated in Table 8.

Figure 20: Component of Traffic Safety

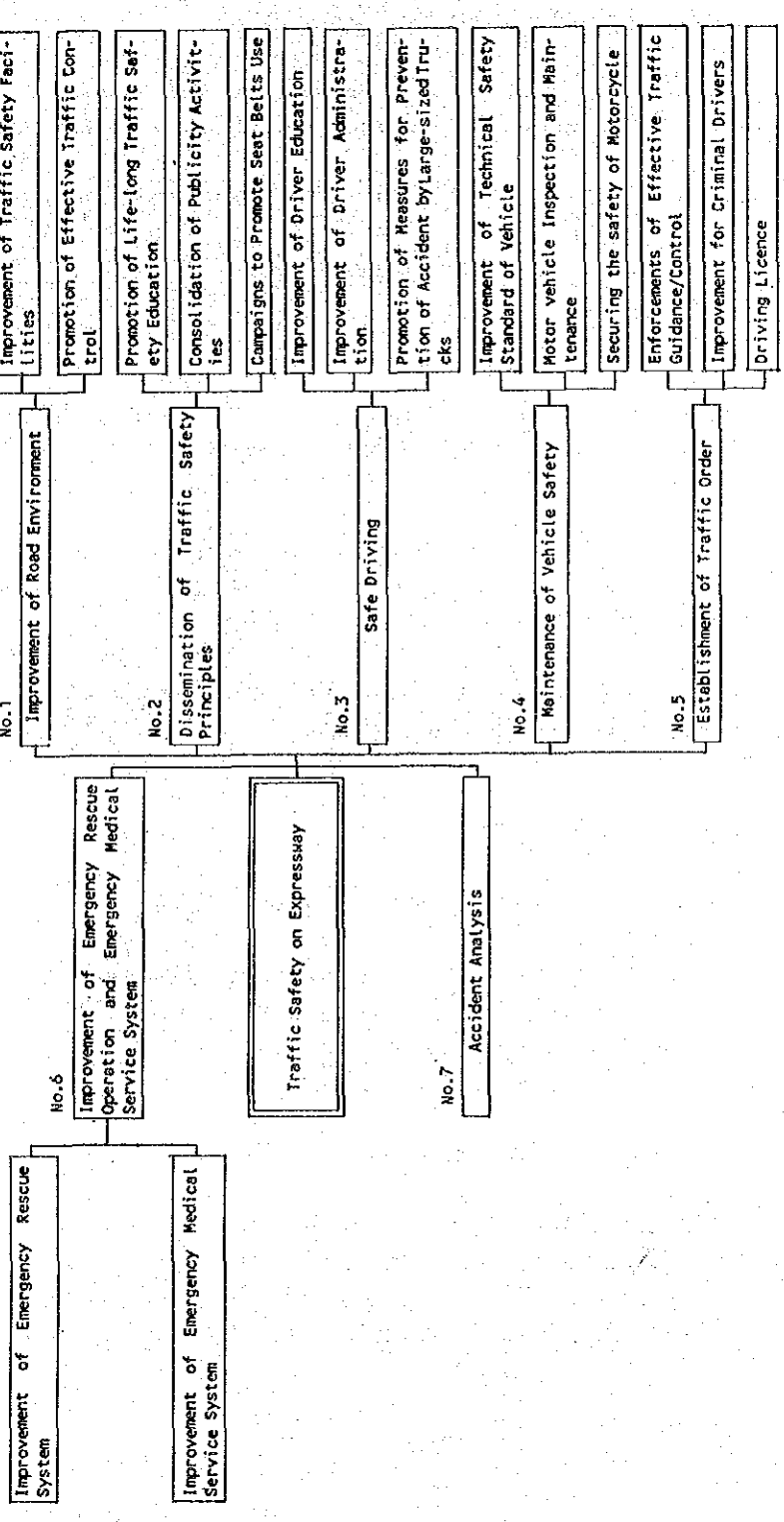


Table 8: Improvement Items for Accident Analysis and Reporting System

Accident Analysis and Reporting System	Improvement Items
Preparation of Accident Analysis and Reporting System	Preparation of Highway Accident Investigation Sheet
	Establishment of Accident Reporting System
	Set-up of Accident Analysis Team

A sample of the Highway Accident Investigation Sheet can be found in the Operation Manual.

c) Traffic Safety Campaign

For traffic safety campaign, the following items are proposed:

i) Public relation activities by MHA,
ii) Publicity of 'Expressway' to road users,
iii) Preparation of expressway map,
iv) Traffic safety campaign on expressway driving.

An example of the safety campaign is illustrated in the Operation Manual.

4.5 Road Maintenance

The purpose of highway maintenance and repair operations are to sustain the roads and associated facilities as initially constructed or as later improved, so that traffic safety, smooth traffic flow and comfort will be achieved and maintained on the expressway and highway.

1) Inspection

Inspections are performed to repair road and maintain them in such condition that no hinderance to traffic will occur. Road inspections are classified into three categories as daily inspection, periodic inspection and incidental inspection. Daily inspection is carried out once a day to inspect the general road and traffic conditions. Periodic inspection is carried out on fixed time cycle to check the conditions of various structures and equipment. Incidental inspection is needed after any unusual incident has occurred such as heavy thunderstorm or major accident.

2) Road Cleaning

Road cleaning involves removing dirt and trash from the road surface and various facilities as to keep the surface clean and avoid traffic obstruction.

3) Vegetation Control

Vegetation control consists of cultivationg new growth, maintaining full-grown vegetation and renewing old and falling vegetation so that grass, plants and trees can fulfill their intended purposes of providing mental refreshment for drivers, creation of scenic beauty and thus help to reduce driving stress, and to conserve the environment.

4) Repairs

Repairs include repair of pavement, earth works, traffic control facility, bridge, tunnel, etc.

5) Maintenance of Road Fixtures, Fittings and Equipment

This item includes the daily inspection, maintenance and repair of buildings, machinery and electrical equipment as well as communication facilities.

Specifically for the establishment of a traffic control and management system masterplan, the inspection and traffic control for road maintenance are the most important.

5.0 PRELIMINARY ENGINEERING DESIGN

This chapter summarizes the preliminary engineering design for the traffic control and management system.

5.1 Emergency Telephone

1) Introduction

Emergency telephone is a communication tool for the road users who need to contact the road management body for assistance in case of accident, car trouble or running out of fuel on the expressway and highway where no other means of communication is available.

2) System Configuration

Emergency telephone system consists of roadside telephones along the expressways and highways, emergency telephone central controller and emergency telephone receiving desk in the control center. Monitoring equipment is provided to the maintenance office to monitor the call from within its jurisdiction and to receive a call when the call is not attended to by the operator in the control center due to multiple calls or malfunction of the center equipment.

3) Type of Telephone Set

The emergency telephone with a built-in speaker, a microphone and a push button is already in use in Malaysia and is recommended to be used on the rest of the expressways and highways.

4) Installation Standard

The interval of 1 km is recommended and guide signs which shows the direction of the nearest telephone set is required at intermediate locations (see Table 7).

5.2 Vehicle Detector

1) Introduction

Vehicle detector is used to detect automatically the up-to-date traffic information such as volume, speed and congestion degree on the expressway and highway. Detector data are then processed collectively in a manner that traffic management officials can continuously monitor the traffic situation for prompt reaction to administer the necessary first aid countermeasures.

2) System Configuration

Vehicle detector system consists of vehicle detectors installed along the expressways and highways, detector data processor at the maintenance office and central computer system at the traffic control center.

3) Type of Vehicle Detector

There are two types of vehicle detectors being used widely, that is loop and sonic detectors. Loop type vehicle detector with two loops at one site is recommended for use on the Malaysian expressway and highways to obtain the more accurate speed data and vehicle classification.

4) Installation Standard

Table 7 mentioned earlier summarizes the installation standards of vehicle detector at each management level.

5.3 Weather Observatory Equipment

1) Introduction

Weather observatory sensors will be installed at the weather observation station along the expressway and highway to monitor the weather conditions with the purpose of preventing vehicle accidents due to the worsening climate conditions. Of various sensors available, sensors for rainfall and winds which have great influence on the Malaysian expressway and highway are recommended and described here.

2) System Configuration

Weather observatory system consists of the rain gauge and anemometer at the outdoor observation station and weather observatory panel with a dot recorder at the maintenance office. Functionally, weather data are sent to the control center for further processing, monitoring and recording.

3) Type of Equipment

a) Rainfall Sensors

Normally, a water faucet measuring 200 mm in diameter is employed. To measure the quantity of precipitation, a turn-over liquid measure system is used in many instances. When liquid measure turns over once with a rainfall of 0.5 mm to 2 mm, one pulse is generated. From the number of pulses, the quantity of precipitation can be found.