8.3 Cost Comparison

Most of the benefits accrued by the traffic control and management system discussed above cannot be expressed accurately in monetary terms. It would be worth while, however, to compare the cost of the system with that of the toll road construction and operation costs to understand its relative magnitude.

1) Comparison with road construction cost

Comparison between construction costs of the roads under study and the system construction cost is summarized in Table 8.3.1 together with the ratio of the latter to the former. Road construction cost shown in the table is an approximate direct cost obtained from the actual cost data for the existing routes and estimates for the planned route. They are re-arranged into the section covered by each maintenance office using unit construction cost per kilo-meter.

Table 8.3.1: Road Construction Cost - System Construction Cost

Section/Route	Distance (Km)	Road Cost Total (M M$)	Road Cost Per Km (M M$)	System Cost Total (M M$)	System Cost Per Km (M M$)	Ratio
Alor Setar	96.7	550.3	5.7	31.1	0.32	5.7%
Butterworth	76.4	520.0	6.8	28.4	0.37	5.5%
Taiping	91.4	666.9	7.3	33.8	0.37	5.1%
Ipoh	87.6	485.7	5.5	47.9	0.55	9.9%
Tanjung Malim	90.3	469.5	5.2	31.3	0.35	6.7%
Kajang	75.9	206.3	2.7	38.9	0.51	18.9%
Ayer Keroh	97.3	420.3	4.3	45.7	0.47	10.9%
Air Hitam	83.5	437.0	5.2	28.8	0.34	6.6%
Skudai	59.1	224.5	3.8	22.4	0.38	10.0%
Sub-total	758.1	3,980.5	5.3	308.3	0.41	7.7%
New Klang Valley Exp.	53.6	316.0	5.9	31.0	0.58	9.8%
Penang Bridge	14.0	729.8	52.1	13.1	0.94	1.8%
Federal Highway	15.0	78.3	5.2	1.8	0.12	2.3%
Senai Highway	28.0			1.5	0.05	
KL - Karak Highway	46.8			21.0	0.45	
Total	915.5	5,104.6	5.6	376.8	0.41	7.4%

Notes: 1) New Klang Valley Exp. system includes Rawang - Bukit Lanjan section of N-S Expressway.
2) Construction cost of Senai Highway and Karak Highway is not known.
3) Karak Highway is only considered for the stretch between toll plaza.

From the table above, it is noted that for the North-South expressway, the average ratio of the system construction cost to the road construction cost is about 7.7%. Relatively higher figure for Kajang section seems to be due to the early construction of the section. The cost of the planned road widening for KL-Seremban section is not included.

On the other hand, the cost ratios for the other routes vary greatly due to the large difference in the road construction cost per kilo-meter. Exact construction cost of Senai Highway and Karak Highway is not known, but M$46.8 million has been spent on upgrading Karak Highway.

Although the number of information sources about the similar comparison is limited, the ratio of the system cost to the road construction cost shown in the table is agreeable with cases in other countries and deems reasonable.

2) Comparison with toll revenue

Based on the traffic volume forecast, the annual toll revenue in future for all the routes under study is estimated. The estimates take the scheduled toll rate increases into consideration for the sections operated by the concession company and assume the toll increase of the same percentage for other routes. The figures are compared with the construction and operation costs of the traffic control and management system estimated in the preceding chapter. The results are presented in Table 8.3.2.

Table 8.3.2: Comparison of Toll Revenue and System Cost

Route	Annual Toll Revenue (M M$) 1988	1995	2005	Construction Cost (M M$)	Annual Operation Cost (M M$)
Toll roads operated by concession company (North-South Expressway, Senai Highway, New Klang Valley Expressway, Federal Highway)	73	434	969	342.6	18.4
Penang Bridge	32	66	145	13.1	1.2
Karak Highway	9	19	40	21.0	1.4
Total	114	519	1,154	376.8	21.0

Should the system construction and operation costs be borne by the motorists, toll may be increased to cover the cost. Necessary toll increase is calculated assuming that the system will be completed 1992 through 1995 and operated for 15 years after the completion, which is a conservative assumption for facilities such as cable. Table 8.3.3 shows the toll increase in percentage to the current toll rate in the case that toll is increased to cover the system construction and operation costs.

Table 8.3.3: Calculated Toll Increase

Route	Construction Cost (M M$)	Annual Operation Cost (M M$)	Toll Increase (%)
Toll roads operated by concession company (North-South expressway, Senai Highway, New Klang Valley Expressway Federal Highway)	344.6	18.4	8.4
Penang Bridge	13.1	1.2	3.2
Karak Highway	21.0	1.4	16.1
Total	376.8	21.0	7.9

Necessary toll increase is about 8% for the entire toll roads. For the routes operated by the concession company, the increase is 8.4% which is close to the average figure. Low percentage of Penang Bridge is due to the fact that the bridge is already equipped with some equipment and amount of additional facilities is relatively low, and its relatively higher toll rate. On the contrary, Karak Highway requires large increase in toll rate to cover the necessary cost. This is attributed to the low toll rate presently adopted.

3) Comparison with vehicle running cost

Running cost of various types of vehicle on the toll roads is calculated. Running costs estimated by Klang Valley Transportation Study are used here with modification to fit the vehicle classification adopted by toll roads. The running costs used are presented below.

Table 8.3.4: Running Cost of Vehicles

Class	Type	Running Cost (cents/Km)
0	Vehicle with 2 axles & 2 wheels	4.7
1	Vehicle with 2 axles & 3 or 4 wheels but excluding taxi	16.7
2	Vehicle with 3 axles & 6 wheels but excluding bus	51.0
3	Vehicle with 3 or more axles	70.1
4	Taxi	12.8
5	Bus	41.3

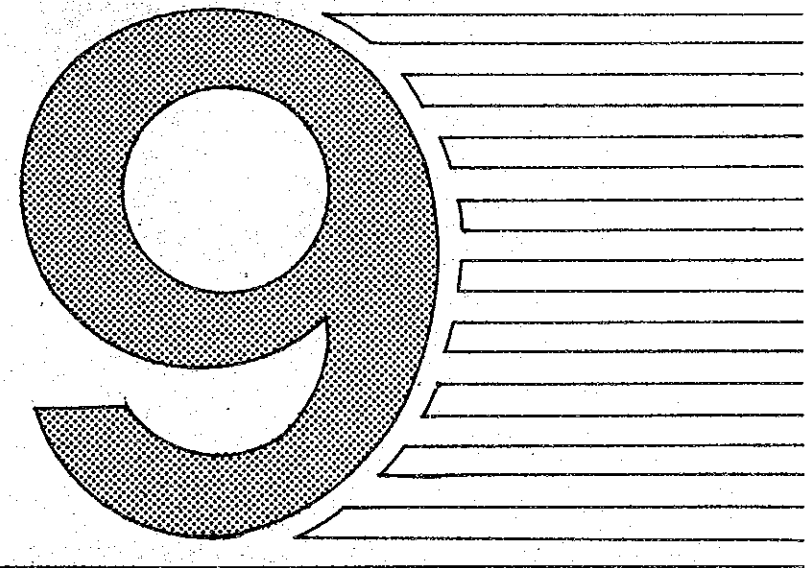
Traffic composition is assumed for each section of the routes based on the survey data shown in Chapter 2. Using composition data, weighted running cost of PCU is calculated. Then, unit running cost is multiplied by the forecasted traffic volume in PCU mentioned in Chapter 3 and section length to obtain the total running cost of the vehicles on the motorway, expressway and toll highways. The results are presented in Table 8.3 5.

Table 8.3.5: Total Running Cost of Vehicle on Toll Roads

Route	Total Vehicle Running Cost (M M$) 1988	1995	2005
Toll roads operated by concession company (North-South Expressway, Senai Highway, New Klang Valley Expressway, Federal Highway)	529	1,676	2,875
Penang Bridge	21	28	45
Karak Highway	76	106	169
Total	626	1,810	3,089

Comparing the system construction, operation and maintenance costs with other costs related to the toll roads, and considering the benefits realized by the system as described in this chapter, 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 is to be borne by them.

CHAPTER



9.0 IMPLEMENTATION PROGRAMME

9.1 Introduction

The preliminary engineering design stage of the proposed traffic control and management systems has been discussed in Chapter 6. The system covers various sections of motorways, expressways and highways which differ in size, complexity and configuration. In addition, some routes are already in use while others are to be constructed. In this Chapter, a standard or typical implementation program of the traffic control and management system is first presented for a representative section. The actual implementation schedule for all routes is then proposed.

The implementation schedule is divided into three steps; detailed design, procurement of contractor, and construction work. However, procurement of contractor is not discussed here as the procedure and schedule vary depending on the method taken.

9.2 Detailed Design

Preliminary engineering design has been conducted by this study and they are presented in Chapter 6. Detailed design is, however, necessary at the next step before the construction of the system begins. Detailed design has two aspects, equipment and system design and installation work design. Different design process will be taken for each sub-system and its installation work. Major activities undertaken during the detailed design stage are:

* Design planning
* Site survey
* Functional design
* Design calculation
* Specification writing
* Preparation of drawings
* Preparation of bill of quantity
* Cost estimation
* Final checking

Duration of the detailed design depends on the kind and number of equipment and length of the section. It is estimated as a typical case that a section under one maintenance office, which is 70 Km to 90 Km in length, requires about eight months for the detailed design assuming that the as-built drawing of the road is available.

9.3 Construction Work

After a contractor is selected, actual construction work of the system begins. This stage is grouped into four parts; communication civil work, communication cable work, roadside facility work, and control center facility work.

1) Communication civil work

This work is to construct underground conduit line for communication cable to be carried out in the following steps:

* Work planning
* Procurement of materials
* Transportation of materials
* Construction work
* Inspection and commissioning

Materials for the work will be procured from either domestic supplier or foreign supplier. In the latter case, sufficient time must be allowed for transportation of the materials to the work site including custom clearance.

Trenching work including, digging, conduit laying, handhole placing and backfilling is estimated to progress 1 Km a day by one party for earth section if machine is used. Therefore, the work will take about three months for the section under one maintenance office. Completed conduit line must be inspected to ensure debris-free inside.

2) Communication cable work

Communication cable is laid through the conduit by this work. As composite cable is used, only one line of cable is laid. The work consists of the following steps:

* Planning
* Procurement of cable and materials
* Transportation
* Laying and splicing of cable
* Testing
* Commissioning

The cable will be made to order by a foreign supplier so that enough time must be allowed for transportation. Precaution is required during cable laying as the allowable maximum tension of optical fiber cable is smaller than the conventional copper cable.

Cable is spliced after laying and various tests are conducted to ensure the correct connection and the required cable characteristics.

3) Roadside facility work

The procedure of roadside facility work is as follows.

* Design approval
* Equipment manufacturing
* Factory test
* Transportation
* Installation work
* Testing and adjustment
* Commissioning

The equipment proposed by the supplier is reviewed and approved at the design approval stage. Then the equipment is manufactured, which takes six to eight months depending on the equipment. Test of the equipment is conducted at the factory at the presence of the client before shipping.

Once the equipment is delivered to the site, they are erected according to the schedule. Footing and support structure for the roadside facilities must be, therefore, constructed timely to avoid delay. Each equipment will be undergone stand alone test after installation to ensure their operation in isolated mode.

4) Control center facility work

A similar procedure as the roadside facility work is taken for the center facilities including computer software. However, the testing and adjustment is more extensive and time consuming as the normal operation of each of the respective equipment as well as that of the whole system must be confirmed.

Facilities not included in the supply contract such as the control center building, power supply, air-conditioning, etc. must be completed well in advance of the equipment installation.

Figure 9.3.1 shows the implementation schedule of a typical section covered by one maintenance office. As shown on the figure, detailed design takes eight months, while construction work needs 22 months resulting in the total duration of 30 months. It must be noted, however, that no time is allotted for the procurement of the contractor.

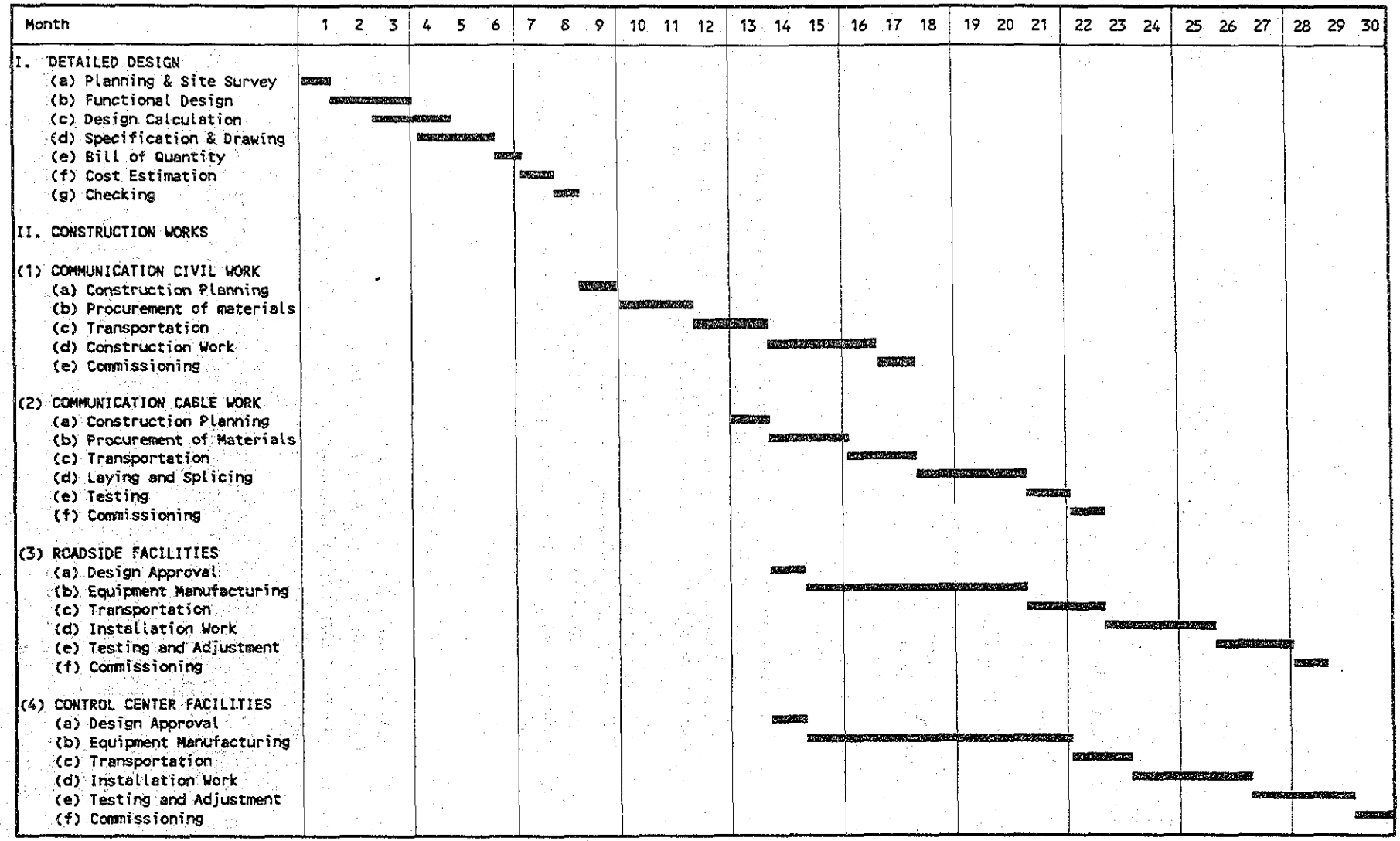


Figure 9.3.1: Typical Implementation Schedule

9.4 Implementation Program

The staging plan of the construction program is proposed in Chapter 5 "Traffic Management Standards". This plan is further elaborated here taking into consideration the implementation process and the difference in the size of the system for each section. However, implementation of only stages 1 and 2, which are to be completed by 1995, are programmed here as the implementation of stage 3 system is beyond 1995 and depends largely on the future traffic development. The implementation program is presented in Figure 9.4.1, which is prepared based on the following assumptions:

* If the section is already in use, the implementation will start as soon as possible.

* If a portion of the road section is yet to be constructed, schedule is set in such a way that the system will be completed at the end of the target year of road construction.

* Contractor procurement period of six months is assumed.

* For the road section to be constructed, communication civil work may be done simultaneously with the road construction work but such arrangement is not considered in the schedule.

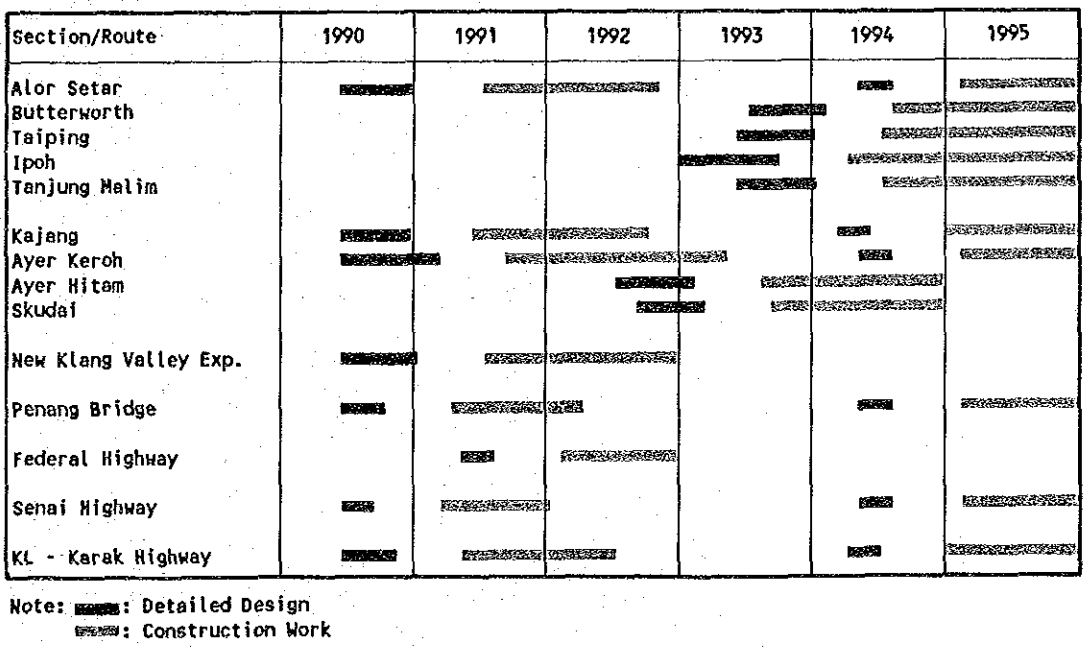


Figure 9.4.1: Implementation Programme

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. The results are presented in Table 9.4.1. The column under "1996-" indicates the cost for Stage 3 system which will be incurred during the years 1996 through 2005.

Table 9.4.1: Annual Financial Requirement

Unit: Million M$

Route	Annual Financial Requirements						Total
	1991	1992	1993	1994	1995	1996-	
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

Note: Figures are rounded up.

Appendix : Installation of Emergency Telephone on Federal Highway from Klang to Subang Jaya

The need to provide emergency telephones along a highway depends largely on the design standards and the development conditions along the highway, particularly on the accessibility to its surrounding areas. In the Klang Valley Transportation Study, emergency telephones have been proposed for highway sections to which access is controlled based on the high level of design standards and the development conditions of the surrounding areas.

In this study, emergency telephones are taken as basic facility to be provided along all motorways and sections of the expressways that have full access control as the road users have no other means of seeking help during an emergency. For sections of the expressways which have no full access control and along which urban development is rapid, the need for emergency telephones, as one of the essential components of a traffic management system, decreases in view of the fact that the road users can easily access to facilities along the expressway in seeking assistance. The Johor Bahru-Senai Highway is a case in point.

With this in mind the study team has re-examined the design standards and conditions along the federal highway. For the 15 km section from Subang Jaya to Klang, there are at least 10 access locations so far, and many of which are at-grade intersections. Moreover, with the rapid urban development along this section of the federal highway, particularly that of Shah Alam, accessibility to facilities during an emergency by the road users has been much improved. The installation of emergency telephone thus has not been recommended within the framework of this Study.

However, such a facility would be an added service that could meet the road users' need for quicker and firsthand communication in emergency, especially to those who are not familiar with the surrounding areas. In addition, the appearance of the facility would give the road users a psychological effect of a safe highway. Hence the study team is of the opinion that the proposal to install emergency telephones should be supported from the viewpoint of achieving a high level of serviceability for the road users along the priority roads.

For the section of Federal Highway, a total of 26 emergency telephones, 13 on each side of the highway will be required. The installation location are shown in the location map below. The additional cost for the emergency telephones amounts to about M$429,000. Additional cost for cable will not be incurred as the cable provided for other equipment is capable of accommodating the emergency telephones. Likewise is the cost of central control equipment which are installed at the same maintenance office. The operation cost for the additional emergency telephones is found to be negligible. The additional cost of the telephones is reflected in the tables below.

Table 1: Construction Cost Estimates by Sub-System

Unit: M$'000

Route/Section	Length (km)	Information Collection System	Information Dissemination System	Information Processing System	Communication System	Total	Per km
NORTH-SOUTH EXPRESSWAY							
Alor Setar	96.7	3,054	1,284	4,182	22,602	31,122	322
Butterworth	76.4	2,928	1,353	4,182	19,893	28,356	371
Taiping	91.4	3,929	3,612	4,182	22,036	33,758	369
Ipoh	87.6	3,688	2,424	17,391	24,389	47,892	547
Tanjung Malim	90.3	3,900	970	4,182	22,209	31,260	346
Kajang	75.9	7,104	8,147	4,182	19,507	38,939	513
Ayer Keroh	97.3	2,402	1,083	17,391	24,866	45,743	470
Air Hitam	83.5	3,771	1,083	4,182	19,770	28,806	345
Skudai	59.1	2,667	1,197	4,182	14,367	22,413	379
SENAI HIGHWAY	28.0	1,182	290	0	0	1,472	53
NEW KLANG VALLEY EXP.	53.6	5,136	3,637	9,040	13,223	31,037	579
FEDERAL HIGHWAY	15.0	1,399	832	0	0	1,802	120
Sub-total	854.8	41,159	25,911	73,096	202,862	342,600	401
PENANG BRIDGE	14.0	2,228	1,528	5,015	4,367	13,137	938
KARAK HIGHWAY	46.8	2,586	662	5,015	12,758	21,020	449
Sub-total	60.8	4,813	2,189	10,029	17,126	34,157	562
Total	915.6	45,973	28,101	83,125	219,988	376,758	411

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 2: Construction Cost Estimates by Stage

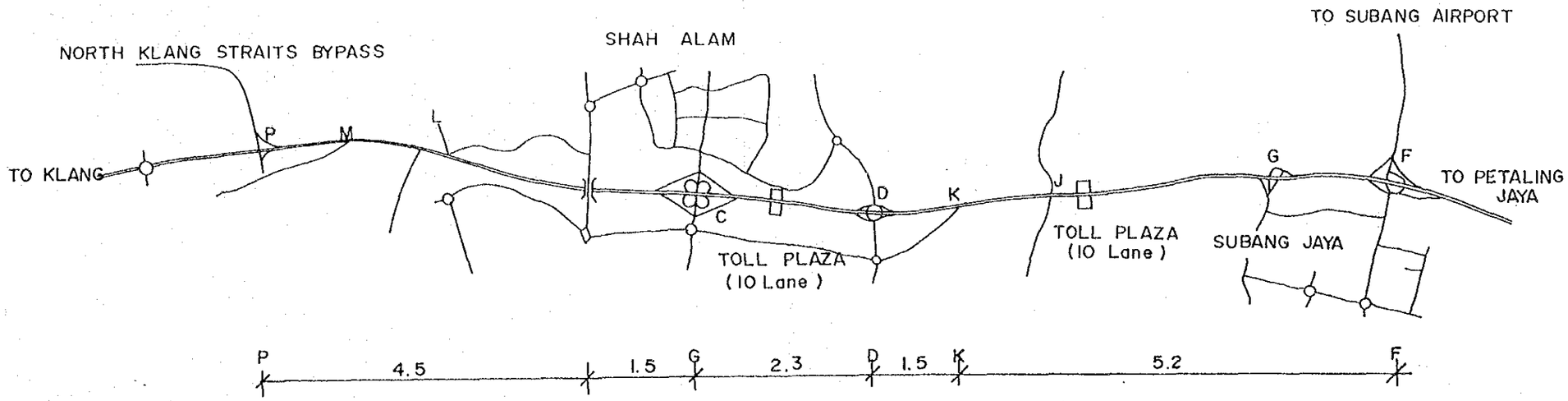
Unit: M$'000

Route/Section	Length (km)	Stage 1	Stage 2	Stage 3	Total
NORTH-SOUTH EXPRESSWAY					
Alor Setar	96.7	29,242	1,197	682	31,122
Butterworth	76.4	0	28,032	324	28,356
Taiping	91.4	0	31,832	1,926	33,758
Ipoh	87.6	146	46,260	1,486	47,892
Tanjung Malim	90.3	0	30,774	486	31,260
Kajang	75.9	27,039	3,702	8,198	38,939
Ayer Keroh	97.3	44,461	1,282	0	45,743
Air Hitam	83.5	0	28,300	506	28,806
Skudai	59.1	0	21,426	986	22,413
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	1,715	517	1,802
Sub-total	854.8	101,178	222,827	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	227,167	20,004	376,758

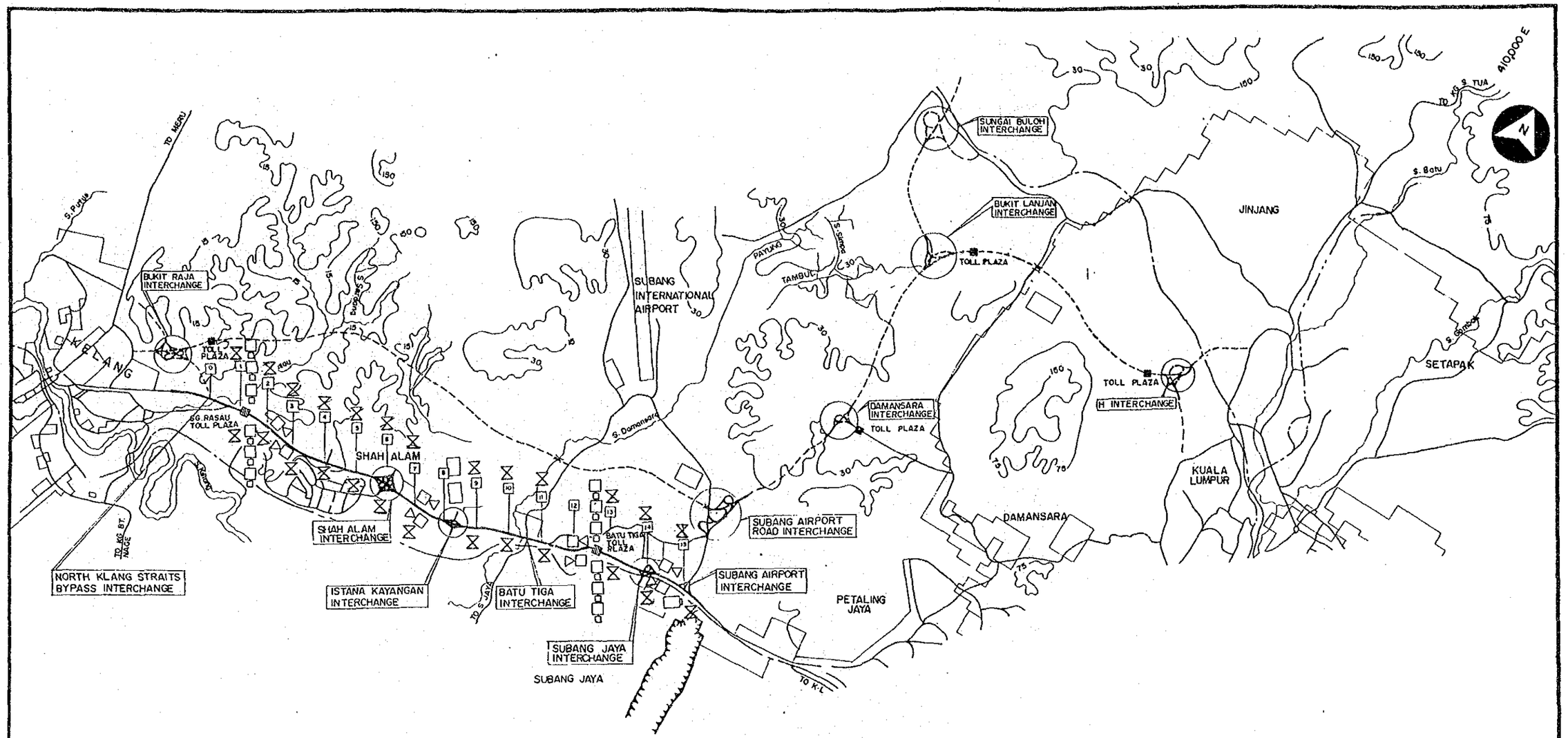
Notes: 1) New Klang Valley Expressway includes 16.6 km of N-S Expressway (Rawang-Bukit Lanjan section).
2) Length of Karak Highway is the stretch between toll plaza.

MAP 1: TRAFFIC CONTROL AND MANAGEMENT SYSTEM PLAN FOR FEDERAL HIGHWAY

FEDERAL HIGHWAY (BERKELEY ROUNDABOUT TO SUBANG AIRPORT INTERSECTION - 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 (Control Centre, Sub centre, Repeater, Trunk Line, Local Line)	Regional Office									
	Maintenance Office Communication Network		To New Klang Valley Expressway							
Emergency Telephone			13 13							
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										



MAP 2: PROPOSED EMERGENCY TELEPHONE LOCATION MAP ALONG FEDERAL HIGHWAY

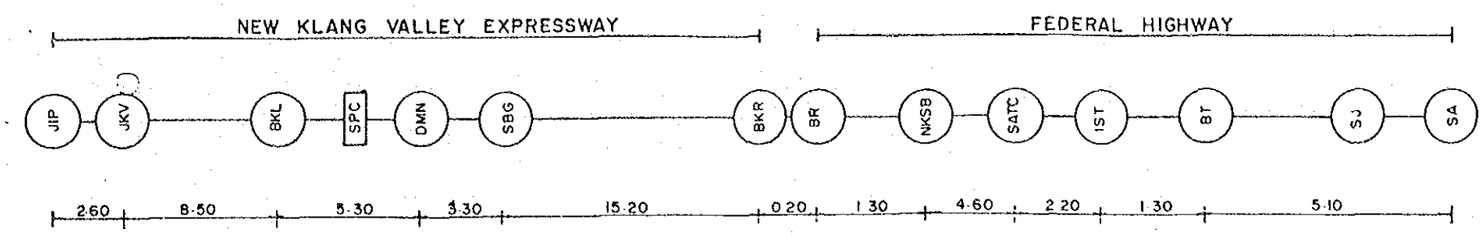
SCALE: 1000 0 2000 / 500 1000 metres

DRAWING NO: B29

DATE: DEC 1989

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

JAPAN INTERNATIONAL COOPERATION AGENCY



COMPOSITE CABLE / CONDUIT LINE

TO N.S. JUNCTION

0SM + 5GI + CCP 09 - 40P (10·6km) VE 54(2)

5SM + 5GI + CCP 0·9 - 40P (8·6km) VE 54(2)

0SM + 5GI + CCP 0·9 - 40P (29·9km) VE 54(2)

HANDHOLE (UNIT): 70 / 70 ; 30 / –

FOUNDATION OF EMERGENCY TELEPHONE (UNIT)

EXPLANATORY NOTES

○·MAINTENANCE OR REGIONAL OFFICE CH

(( ))·(○)·○·○)

└ TRUNK LINE CH

└ COMMAND TELEPHONE CH

└ TOTAL LOCAL LINE CH

·3P · NUMBER OF PAIRS

·(2)· NUMBER OF CIRCUITS

NAME OF EQUIPMENT	IF	CABLE									
EMERGENCY TELEPHONE	ETEL	3P	3P(2)	3P(2)	3P(2)	3P(2)	3P(2)	3P(2)	3P(2)	3P(2)	3P(2)
EXCLUSIVE TELEPHONE	2W	1P	(5)	5P(5)	5P(5)	(16)	(5)	(5)		(5)	
COMMAND TELEPHONE	CTEL	1P	(2)	2P(2)	2P(2)	(2)	(2)	(2)		(2)	
RADIO STATION	4W	5P	(1)	5P	5P	(1)	5P	5P	(1) 5P	(1)	5P (1)
HIGHWAY RADIO	4W	3P									
CHANGEABLE MESSAGE SIGN	4W		(4)			(4)		(2)			
MAINLINE		2P	2P(1)	2P(1)	2P(1)	2P(1)					
ACCESS ROAD		2P	2P(1)	2P(1)	2P(1)	2P(1)	2P (1)	2P(1)			
TUNNEL		2P									
VEHICLE DETECTOR	4W	2P	2P(1)	6P(2)	4P(2)	10P(5)	2P(1)	2P(1)	2P(1)	2P(1)	
WEATHER OBSERVATORY	4W	2P									
SPEED LIMIT SIGN	4W	2P									
CLOSED CIRCUIT TELEVISION	4W	2P		2P(1)	2P(1)						2P(1)
COMMUNICATION SYSTEM SV	4W	2P	(1)	2P	2P	(2)	2P	(2)	2P(1)		
TOLL COLLECTION SYSTEM	4W	2P	(1)	2P(1)		(1)		(1)		2P(1)	
INTERFACE TOTAL	ETEL		4	④ ((14))		2		–		–	
	CTEL		4	④ ((16))		2		2		2	
	2W		10	㉑ ((45))		5		5		5	
	4W		11	⑭ ((42 + 16 + 0 + 58		7		7		4	
METALLIC CABLE TOTAL			29Px1·5 + 43·5 + 40P		29Px1·5 + 43·5 + 40P		26Px1·5 + 39 + 40P				

MAP 3: COMMUNICATION CABLE INSTALLATION PLAN FOR FEDERAL HIGHWAY

SCALE:

DRAWING NO: C33

DATE: DEC 1989

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

JAPAN INTERNATIONAL COOPERATION AGENCY