9

PRELIMINARY DESIGN FOR PRE-TRIP TRAVELLER AND EN-ROUTE DRIVER INFORMATION SYSTEMS

9.0 PRELIMINARY DESIGN FOR PRE-TRIP TRAVELLER AND EN-ROUTE DRIVER INFORMATION SYSTEMS

9.1 System Architecture

The proposed integrated traffic information system which offers two main user services of pre-trip traveller information and en-route driver information systems, consists of three functional subsystems, namely information collection, information processing and information dissemination subsystems. *Figure 9.1.1* shows the system architecture of the integrated traffic information system.

In the information collection system, vehicle detectors and TV cameras are used to automatically collect traffic information. In addition, operator at the ITIS Centre is able to monitor traffic by observing images taken by the TV cameras. Various traffic-related information will also be collected from other information sources. Data and information may be exchanged automatically with other traffic management systems, if appropriate communication interface and protocol are installed.

Database forms the core of the information processing system. It basically contains the traffic condition data, incident data and system operation data. All incoming data is processed and converted to suitable format before being stored in the database. Traffic condition and incident data are retrieved, selected and edited into the contents and format suitable for each type of information dissemination device.

Pre-trip traveller information and en-route driver information are disseminated through different media. Pre-trip traveller information utilises existing communication infrastructure and covers a wide area. The information provided is thus more general in nature than those for en-route driver information system. Some of the information to be provided are interactive and the user can in fact specify a specific area or type of information needed. On the other hand, en-route driver information is provided through roadside facility and information is mostly location specific except those by broadcasting.

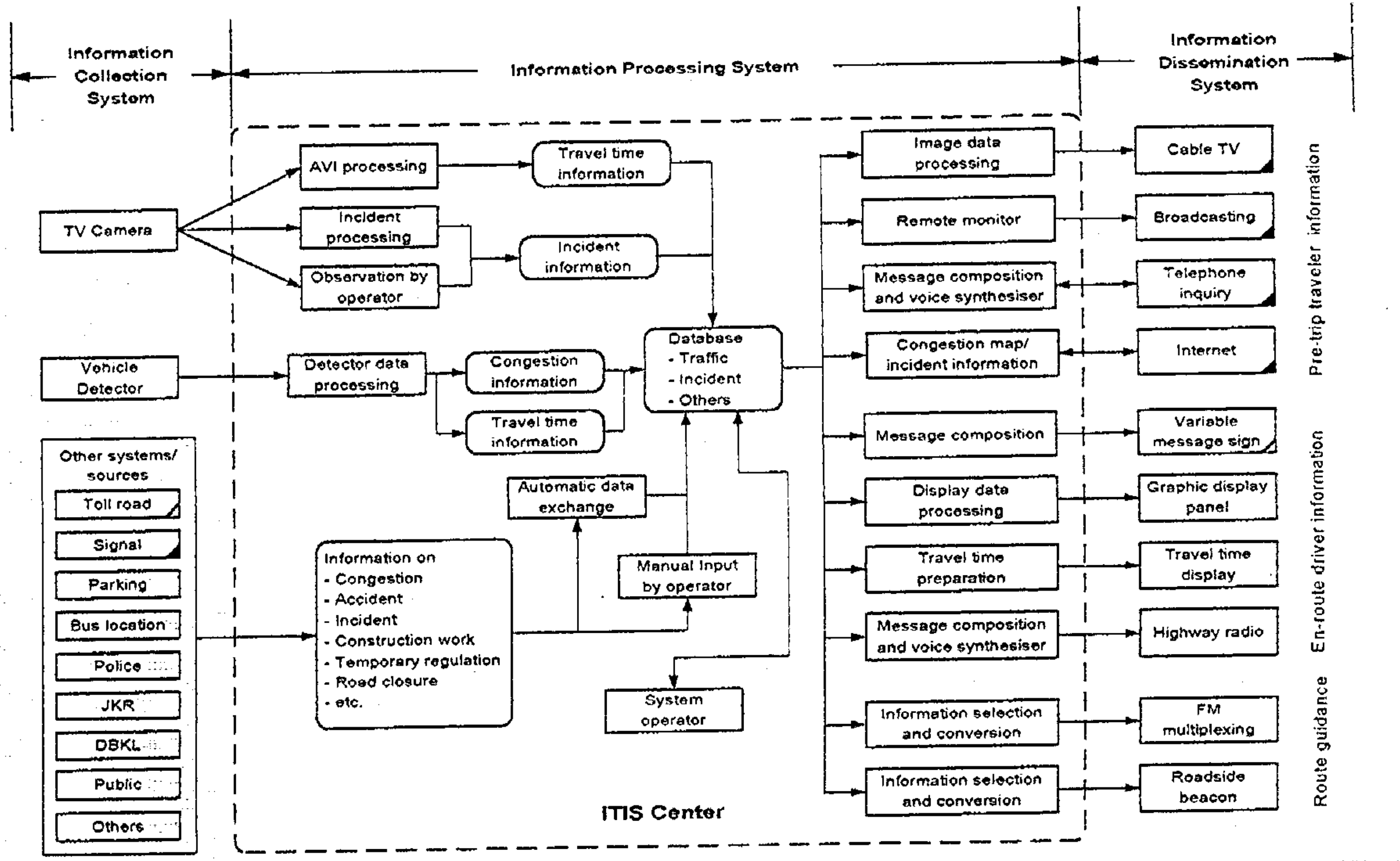

Figure 9.1.1 System Architecture of Pre-trip Traveler Information and En-route Driver Information Systems

9.2 Information Collection System

9.2.1 Collection Devices

Traffic congestion, incidents, construction work, temporary regulation, and other information that affect the traffic flow will be collected both automatically and manually. Automatic means here include the use of vehicle detector and TV camera, and data exchange with other systems. Traffic flow parameters such as traffic volume and speed will be collected automatically. The table below summarises the automatic data collection method and *Figure 9.2.1* illustrates a typical example of a traffic information collection system set-up.

Table 9.2.1 Automatic information collection

Method	Information collected	Remarks
Vehicle detector	Congestion is detected and its severity is judged by processing data from vehicle detectors.	Volume count and time occupancy are data obtained directly by detector.
TV camera	Incident is detected automatically by processing the image data.	Fixed head TV camera is required
Data exchange with other systems	Congestion, incidents and other data are exchanged with other traffic management systems.	Possible candidate includes some of toll road systems and DBKL ATC signal system.

All types of traffic information including congestion, incident, and other events that affect traffic flow will also be collected manually. The operator is required to input such information thus collected into the system in the required format. Updating these information is also necessary and important, so as to provide correct and latest information to drivers and potential road users. Manual information collection is made by two methods as shown overleaf (Table 9.2.2).

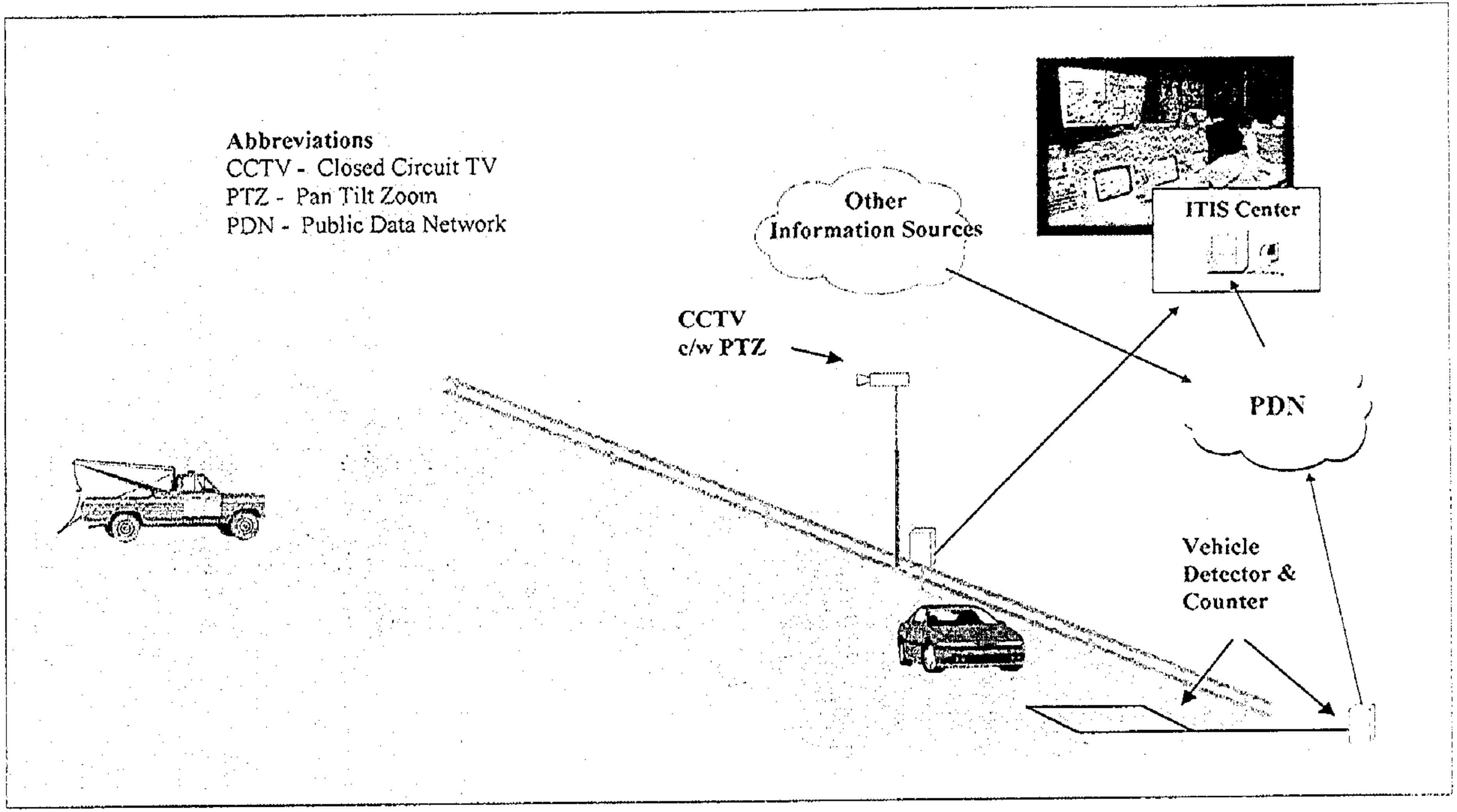

Figure 9.2.1 Typical Traffic Information Collection System Setup

Table 9.2.2 Manual information collection

Type	Information collected	Remarks
TV camera	Operator at ITIS Centre identifies incident by observing traffic flow on the TV monitor.	Congestion and incident
Human communication	Incident information is collected through fixed line telephone, hand-phone and wireless walky-talky.	All types of traffic information

More detailed description of information collection methods is presented below.

9.2.2 Vehicle detector

Vehicle detector will be installed to gather traffic condition on the road. Their main purpose is to detect the occurrence of congestion, which is possible by detecting the presence of slow moving vehicle or queue. The table below shows the detector deployment guideline.

Table 9.2.3 Detector Deployment Guideline

Road	Road section	Detector location
Toll road and highway	Congestion prone section	Every 500m
	Section with AADT > 70,000pcu	Every 1km
	Other sections	One between major interchanges
Arterial road	Road leading to bottleneck	300m, 600m, 1km from bottleneck
	Along arterial roads	Representative location for traffic condition and travel time

At the basic design stage, the number of vehicle detector locations is estimated based on the number of links in each phase, general traffic condition at each link and the deployment guideline presented above. The result is summarised in the table below. Assuming that two detector units (loop coil or ultrasonic head) are installed at each detector location covering two lanes, the number of detector units will be 3, 588 in Phase 1, and 2,108 units in Phase 2, or 5,696 units in total.

Table 9.2.4 Number of Vehicle Detectors

Road	Phase 1	Phase 2	Total
Number of detector locations	1,794	1,054	2,848
Number of detector required	3,588	2,108	5,696

a) *Detector Type and Installation Method*

Two types of vehicle detector will be used, ultrasonic vehicle detector and inductive loop detector. Overhead and side-fire installation method will be adopted for ultrasonic detector. Overhead installation will only be used at locations where existing structure such as fly-over and pedestrian overpass is available for detector installation to avoid the requirement of pole and mast-arm, and also for aesthetic reason. Side-fire installation is used for detection of congestion or queue. Detector will be installed either at the road median or roadside facing the nearest traffic lane. They will measure the presence and speed of vehicles on the lane nearest to the detector.

There is no specific site condition required for the installation of inductive loop detector as long as the traffic flow can be regulated. Loop wire is susceptible to breakdown due to repeated heavy vehicle load, deformation of pavement, digging work, etc. This Study suggests that an investigation be carried out to study the major causes of the loop cut of the existing loop detector and devise improvement to the installation method to minimise the number of possible malfunctioned detectors in future. Table 9.2.5 presents a comparison between ultrasonic detector and inductive loop detector and Table 9.2.6 summarises the detector type and installation method.

Basically, ultrasonic detector will be used at location where site condition permits it. Otherwise, loop detector will be applied. It is estimated that of the total estimated number of vehicle detectors required, about 30% will be ultrasonic type while the rest will be inductive loop type.

Table 9.2.5 Comparison of Vehicle Detector Types

	Inductive loop	Ultrasonic		Image sensor (TV camera)
		Overhead installation	Side-fire installation	
Detection Principle	Change in loop inductance caused by ferrous material	Detection of reflected ultrasonic wave within the pre-set gate time	Same as overhead	Change in the colour/ brightness of each pixel
Measurement	Continuous	Sampling (50msec)	Sampling (50msec)	Sampling (33msec)
Items measured				
- Traffic volume	◎	◎	◎	○
- Occupancy rate	◎	○	○	○
- Speed	○1/	○1/	○1/	○
- Congestion	○	○	○	○
- Incident	Δ	Δ	Δ	○
- Classification	○ Two types by vehicle length	○ Two types by vehicle length 2/	○ Two types by vehicle length	Δ
- Standing vehicle	○	○	○	○
Accuracy	◎	○	○	Δ
Aesthetics	◎	Δ	○	○

	Inductive loop	Ultrasonic		Image sensor (TV camera)
		Overhead installation	Side-fire installation	
Installation	Δ	O	◎	O
- Sensor	Embedded in pavement	Mounted on gantry or mast-arm	Mounted on straight pole on median or shoulder	Mounted on gantry, roadside pole or building nearby
- Pavement work	Sensor installation	None	Cross road conduit, if any	None
- Road closure	Lane by lane	All lanes for gantry, if used	During conduit installation	All lanes for gantry, if used
Maintenance	Δ (replacement of loop)	O (Access to overhead sensor)	◎	Δ (Access to camera, technical skill)
Cost				
- Equipment	◎	O	O	Δ
- Installation	O	O (if existing structure is used) Δ (pole/gantry is installed)	◎	O (if existing structure is used) Δ (pole/gantry is installed)
- Maintenance	Δ (loop coil replacement)	◎	◎	Δ (expensive parts)

Notes: 1: Using two sensors.
2: Classification by vehicle height is also possible.

◎: Very good O: Good Δ: Average

Table 9.2.6 Detector Type and Installation Method

Detector	Location	Remarks
Ultrasonic	Toll road and highway with centre median or sidewall.	Side-fire type
	Location where the existing overhead structure is available for detector installation	Overhead type
Inductive loop	Location other than above	Embedded in the pavement

b) *Single Sensor and Double Sensor*

Both loop detector and ultrasonic detector can have two sensors per detector unit for better measurement accuracy. In double sensor configuration, two sensors are placed few metres apart longitudinally. The table below compares two configurations. As shown in the table, double sensor configuration is better than single sensor configuration in measurement accuracy and maintenance. But the cost of equipment is higher for double sensor type due to additional sensor. Basically double sensor will be applied to the road section where vehicle speed is high such as toll roads and highways.

Table 9.2.7 Comparison of Single Sensor and Double Sensor Configuration

Item	Single Sensor	Double Sensor
Traffic volume	Often produces under count.	More accurate count can be obtained using the equation: $Q = Qs + Qr - Qv$
	O	◎
Speed measurement for congestion level	The following two methods can be used: - Average vehicle length - V-Occ graph The second method is relatively better but error is still in the range of ±10 km/h.	Produces accurate speed measurement.
	O	◎

Item	Single Sensor	Double Sensor
Speed measurement for travel time estimation	Data contains errors and not applicable to travel time estimation. Δ	Can be used for travel time estimation. ◎
Detection of sensor malfunction	Total breakdown can be detected. But degraded detection accuracy is impossible to detect. X	Comparing volume and occupancy data from two sensors, not only total breakdown but also abnormal detection can be detected. ◎

Notes: *Occ : Occupancy*
Qs : Pulse count at first sensor
Qr : Pulse count at second sensor
Qv : Number of pulses that have passed normally both first and second sensor
◎: Excellent O: Good Δ: Poor X: Not suited

c) Detector Data Transmission

Raw detector data will be transmitted to the ITIS Centre in the form of detection pulse through the low speed telephone line leased from the telephone company, or through privately owned cable by toll road concessionaire, if it is available. Detector data from several detector units will be multiplexed into a data stream before transmission to reduce the number of circuits required. A maximum of sixteen detector channels will be provided to each circuit. More details of the transmission system will be given later.

d) Detector Data Processing

Detection signal from vehicle detector is processed at the ITIS Centre to obtain the required data. The following processing is applied to the detection data:

- Verification of detection data
- Conversion from individual detector unit data into detector location data
- Accumulation of traffic counts
- Calculation of average speed
- Determination of service level
- Calculation of queue length
- Detection of incident
- Travel time estimate
- Logging of detector data and malfunction record.

Any detection signal received is first subjected to verification before further processing to remove any of the erroneous data sent from malfunctioned detector. Next, the data at each detection location is obtained by combining the data from all detector units at the location.

Traffic volume data is obtained only for the detector location where detector unit is installed at all lanes. If detector is installed at representative lane only, volume is not accumulated. Based on the detection location data, service level is determined for toll road and highway in which interval between interchange is long. For arterial streets with bottleneck, queue length from the bottleneck is calculated. Service level and queue length information is then registered as traffic information.

Travel time along the selected route is calculated for display on travel time display in Phase 1. Travel time along all links will be obtained for dissemination to in-vehicle car navigation unit in Phase 2.

9.2.3 TV Camera

TV camera will be installed for automatic incident detection and general observation of traffic. For incident detection, fixed head type camera is installed at accident-prone road sections. The image data captured by the camera is processed by computer software and an incident is detected from any abnormal movement of vehicles, such as sudden stop or sudden change in movement direction. An alarm will be issued when the system detects any such possible incident for further confirmation and proper action by the operator.

For general observation of traffic, TV camera mounted on a movable head will be installed at locations having commanding views of road sections with heavy traffic.

Table 9.2.8 Camera Type and Installation Location

Type	Toll road and highway	Arterial roads
Fixed head camera	• Accident prone section	• Accident prone section
Movable head camera	• System interchange • Major interchange • Congestion prone section	• Major intersection

The locations of TV cameras of the existing, proposed for Phase 1 and proposed for Phase 2 are presented in *Figure 9.2.2.*

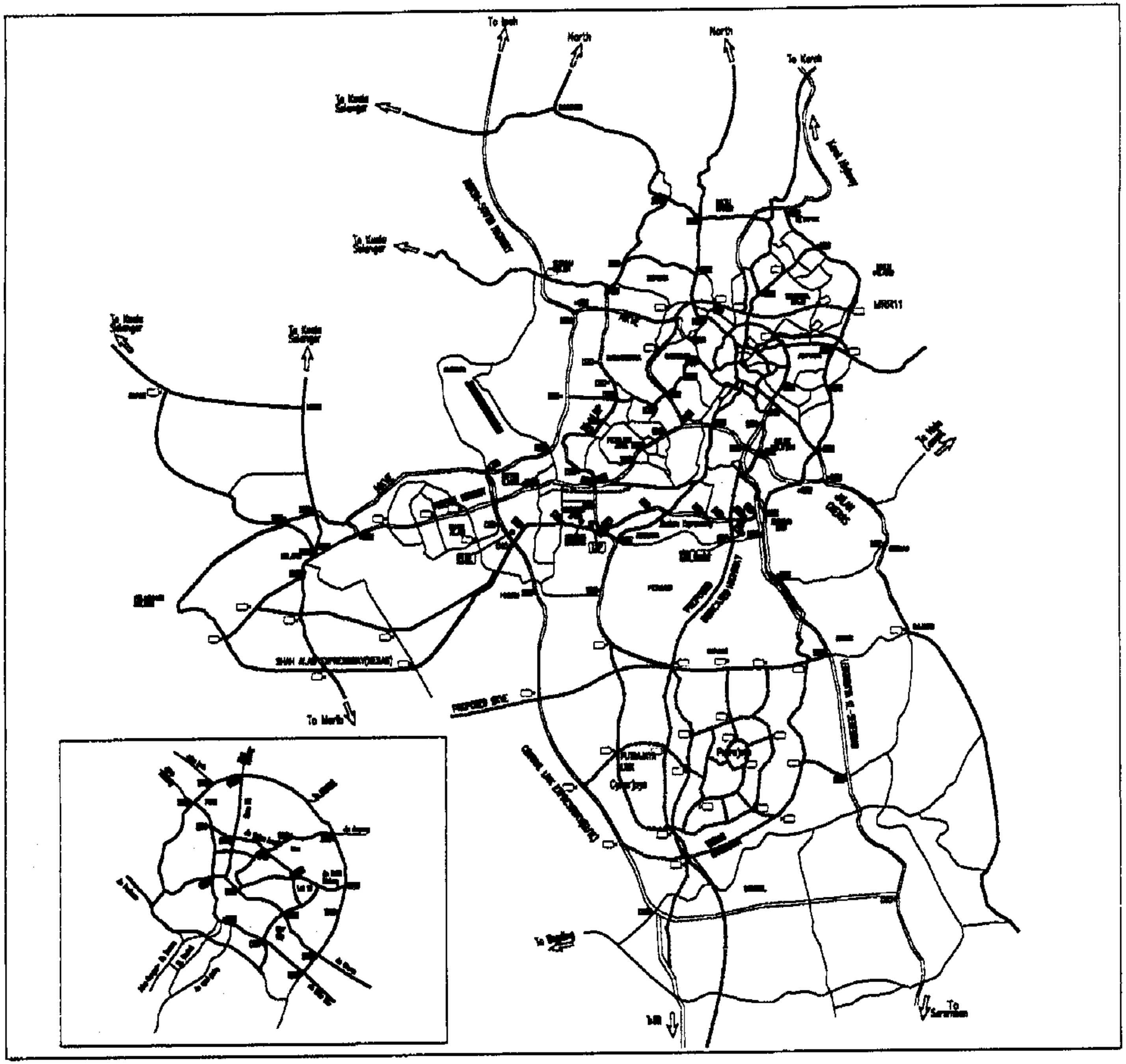

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Figure : 9.2.2

CCTV Camera Locations

LEGEND :

- EXPRESSWAY/HIGHWAY
- MAJOR ARTERIALS
- MAJOR DISTRIBUTORS
- FUTURE ROADS

Existing Camera (32)
DBKL (10)
Elite (6)
Kesas (8)
LDP (8)

New Camera (Phase 1) (60)

New Camera (Phase 2) (46)

0 5 10km
Scale :

N

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Video Signal Transmission

Video output signal from camera has a bandwidth of 4 MHz and requires a wide band transmission system. There are a variety of video signal transmission systems from base band analogue method to digitised and compressed method. Each method has certain advantage over the other methods in terms of carrier frequency, bandwidth, repeater interval, equipment cost and operation cost. Another factor to be considered in selecting transmission method is that optical fibre cable may be available along some of the toll roads in the study area. The basic policy is that several transmission methods will be used in combination depending on the distance and availability of existing cable. Video image with lesser number of frame than standard and some losses of image quality due to compression are acceptable to lessen the requirements for transmission line. Telephone grade transmission line is required to send control signal from the ITIS Centre to the camera controller on site.

9.2.4 Data Exchange with Other Systems

There are a few traffic monitoring or control systems operating in the study area. For example, Kuala Lumpur City has an area traffic control system which controls about 100 signals in the city. Toll road monitoring and information system is introduced to toll roads such as those operated by LDP, Kesas, and Elite. These systems collect traffic-related information that is valuable to the road users. By establishing communication link with these systems, information can be exchanged. Many details of the data exchange such as type and format of information, communication protocol, frequency, monitoring and management, sharing of operation cost, etc. must be studied and agreed upon however before the data exchange can be realised.

Basically, two types of information, traffic condition and system operation, will be exchanged as shown in the table below.

Table 9.2.9 Data Exchanged

Category	Type	Data/Information	Interval/timing
Traffic condition	Detector data	Traffic volume Speed Congestion level Queue length	5 minute
	TV Camera	Video image	Continuous
System operation	Roadside display	Variable message sign	As updated

Detector data processed at respective control center will be transmitted to ITIS center at regular interval, 5 minutes for example. Data is prepared in units of each detector locations. A table that defines the detector code used in each system and its location must be prepared to utilise the data sent from other centers.

The necessary number of video transmission channels will be established between the center of other systems and ITIS Center. Video images taken by TV cameras of other systems are simultaneously sent to ITIS Center for monitoring. Control of camera (power on/off, pan, tilt, zoom, etc.) will be done by the respective systems.

Messages shown on the variable message signs of other systems will be monitored at ITIS Center. Depending on the transmission method adopted by the existing variable message sign system, the data of the message being displayed are sent as character code or bit pattern. In both cases, transmission protocol and data format must be established.

9.3 Information Processing System

Information processing system at the ITIS Centre will be a computer network, in which several computers and other devices are inter-connected through a local area network (LAN). The network must be fast enough to handle a bulk of data exchanged between computers; designed and configured in such a way that malfunction of a unit will not affect the normal operation of other units in terms of hardware, and interruption of data flow and processing will be minimised.

Functionally, the centre system performs the following tasks:

- Processing of gathered traffic and incident data
- Incident selection and message preparation
- Human-machine interface
- Database management
- System administration

The first two items have already been explained briefly in the preceding sections. The other three are described below.

9.3.1 Human-machine Interface

The following two devices are used for human-machine interface in the Centre in addition to the system console, which is intended for the maintenance staff:

- Wall map display
- Operator console

Wall map displays traffic condition, video image, and system operating condition on a large screen. Projector type wall map display is recommended for its flexibility over fixed mosaic tile type. Among the projector types, one using digital micro-mirror device is recommended for its brightness and relatively lower maintenance cost. The screen consists of several units of projector and they will be capable of displaying one image individually on each screen, or one large image covering all screens.

Operator console provides operator with access to the system. Various data and information are displayed on the monitor automatically or upon operator's request. They will also be printed as report. Graphic user interface will be adopted for easy and error free operation. Suitable access control according to the access right, and security measures such as password are required to protect the system against the unauthorised access.

9.3.2 Database

A real-time database will be established in the control centre system. The database must be capable of coping with the requirements of the on-line real-time traffic information system and operating without manual intervention or periodic shutdown. The database will collect and store the following data:

- Traffic information
- Incident information
- System administration

Traffic data gathered by vehicle detector is periodically compiled into suitable form and stored in the database. The data can be retrieved upon manual request. Likewise, all incident data are logged into the database for easy search and retrieval.

Operation record of all equipment comprising the system is stored in the database. The record will include not only the operation mode, status and error code of the equipment but also message and information displayed on the signboards.

In addition, the database will hold the system parameters and constants that define the system configuration, code number of various equipment, relationship and connection between devices, factors and coefficients used in data processing, location name, etc.

A tool will be provided to manipulate both variable and constant data in the database with the adequate security measures. The tool must be GUI based and fool-proof to avoid interruption of normal operation due to erroneous data accidentally input to the database.

9.3.3 System Administration

Administrative operation includes the monitoring of system performance, modification of system configuration, start-up and shutting-down procedure, connection and disconnection of system components, system and component testing, system clock adjustment, and other operations related to the system administration.

Operation of all outdoor terminals, central equipment and transmission equipment are continuously monitored by the system. If a malfunction is found, an alarm will be issued depending on the nature of the fault. It will be possible for the system operator to disconnect malfunctioned device from the system.

As the system is connected to Internet through a content server, necessary precautions must be implemented including firewall and access monitoring,

9.4 Information Dissemination System

9.4.1 Information Dissemination Facility

Traffic data and information that the system collects is first processed and compiled into information in a specified format suitable for database storage. For preparation of message, incident information is retrieved from the database, prioritised according to the priority, which is different for each signboard at different location, and converted into a suitable format. Information is disseminated to drivers and potential road users through various means. *Figure 9.4.1* illustrates a typical example of a traffic information dissemination system set-up for both pre-trip and en-route information. The following media will be used for the information dissemination:

For pre-trip traveller information:

- Telephone inquiry
- Internet
- Radio broadcasting
- TV broadcasting
- Cable TV

For en-route driver information:

- Variable message sign
- Graphic display board
- Travel time display
- Highway radio

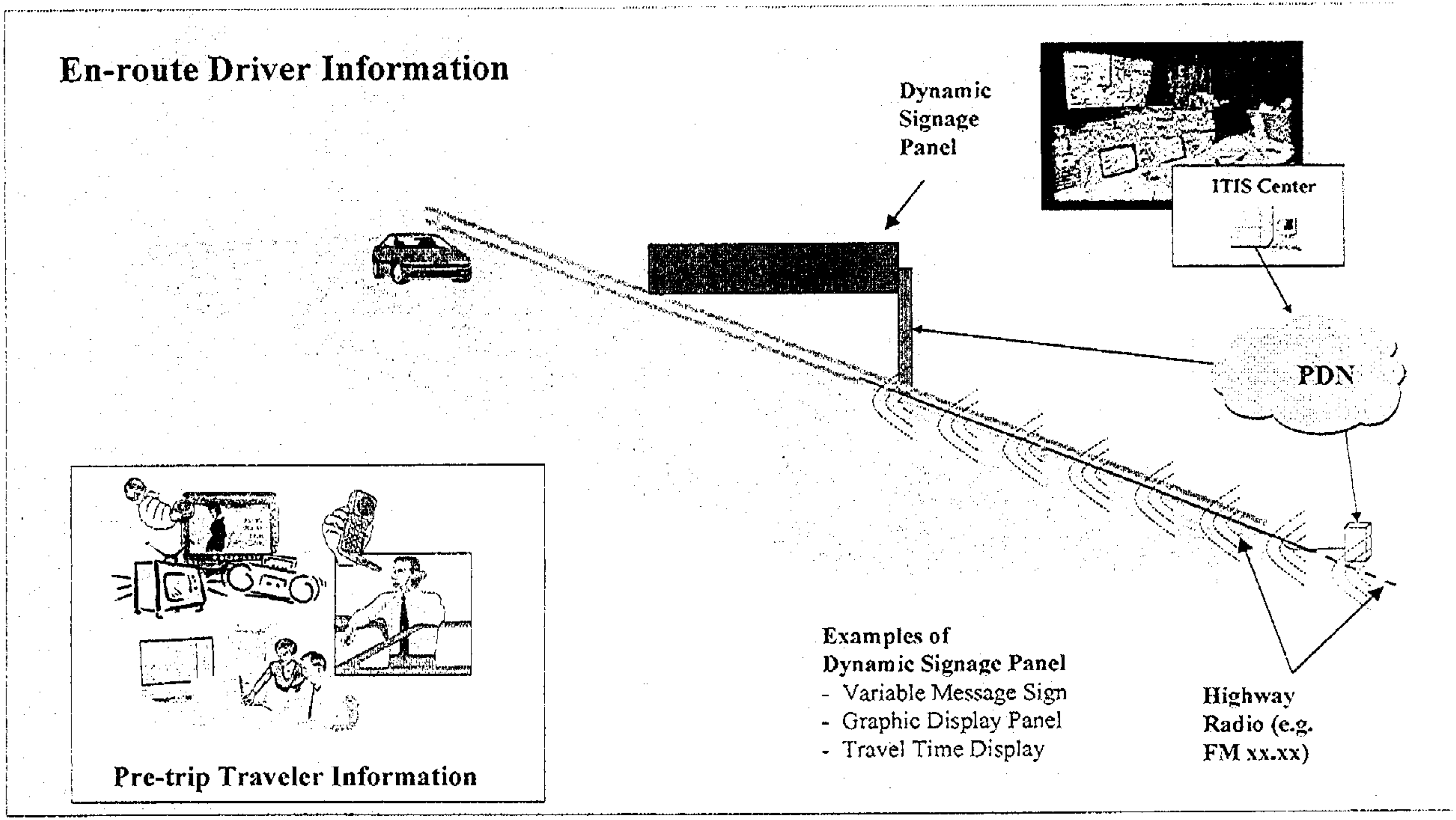

Figure 9.4.1 Typical Traffic Information Dissemination System Setup

9.4.2 Facilities for Pre-trip Traveller Information System

Pre-trip traveller information system provides potential road users with the traffic congestion information and other traffic-related information. Media used for information dissemination can be classified into two types. Interactive type uses telephone or Internet and responds to user's request on the information needed. Broadcasting type media delivers information uniformly to all listeners or viewers. Thus, the information will be more general and area-wide than the interactive type.

a) Telephone Inquiry

Traffic information can be obtained through telephone. Potential road users who want to obtain the information call a specified telephone number to the ITIS Centre. The automatic telephone answering system guides the caller through a menu by pressing the appropriate numbers to select language and geographic area for which he/she wants to get the information. Messages composed from pre-recorded phrases will be played back. The information is updated automatically at every five minutes. All processes are made automatically without any operator's help. But information can be provided manually by the operator for the information that is not automatically available, for instance, an upcoming event.

b) Internet

A web site of the proposed ITIS Centre will be established to provide traffic information through the Internet. Traffic information is offered in three formats. A road network of current congestion map will be prepared by the Internet contents server. The map shows the average speed of the road sections where detectors have been installed. In addition, information such as the location of accident, road construction or repair work and temporary traffic control regulation are marked on the map manually by the operator. Travel time information between major points may be added to the map. Such a map is posted on a web site and automatically updated every five minutes.

A list of incidents will also be posted on the web site. The list shows congestion, accident, road construction work, traffic regulation and other events that affect traffic flow. Both on-going and upcoming incidents are also listed.

Video image taken by TV camera can be provided through the Internet. Special compression technique such as MPEG4 is required to overcome the very slow transmission speed usually used to access Internet. Quality of video image sent over the slow transmission line will not be very fine but is good enough for traffic observation.

c) *Radio Broadcasting*

Broadcasting service of traffic information is already in operation. But the information currently provided by the existing system is rather limited and descriptive in nature. A remote monitor terminal will be installed at the broadcasting station. More accurate information such as estimated travel time and queue length will be provided through it. The staff of the broadcasting station selects the actual information and message to be announced.

d) *TV Broadcasting*

Traffic information is also disseminated through TV broadcasting much like weather reports. Congestion map showing the current congested locations will be presented together with other information such as accident, construction work and temporary regulation.

e) *Cable TV*

A cable TV service is provided in the area by MAXIS. Their service covers Kuala Lumpur, Petaling Jaya, Subang, and Sungai Buloh with a total number of subscribers of approximately 13,000. Cable TV can be a good media to provide traffic information in graphic to the general public as no investment is required on the viewer's side and no knowledge of equipment operation is necessary. Initial investment on the provider side is small, as only the equipment necessary to connect ITIS Centre with cable TV provider is required.

Information may be distributed in three ways like information through Internet. Congestion map prepared by the Internet server will be converted to TV signal format. The image taken by TV cameras installed at various locations in the study area can be distributed. Multiple cameras will be scanned sequentially and the view of camera site taken by the TV camera will be directly distributed together with location name added to the screen. The third item is the list of incidents such as accident, construction work, events, etc. The information covers both present incidents and scheduled one like special events.

The first method can provide an overall view of congestion in the study area. Because cable TV is not interactive, it is not possible to provide detailed congestion map in a zoomed-up format. The second method provides the first hand view of traffic conditions. But as the number of camera increases, the rotation cycle of all cameras may become longer.

9.4.3 Facilities for En-route Driver Information System

Four types of road sign facilities will be used for information dissemination for drivers on the road, namely, variable message sign, graphic display panel, travel time display and roadside highway radio. Variable message sign provides information in characters. This facility is already installed on some of the toll roads in the study area. Graphic display panel shows the congestion information on schematic road network map. Travel time display indicates the estimated travel time from the signboard location to selected destinations. Highway radio provides neighbourhood traffic information through the car radio.

An incident prioritisation procedure is required for the variable message sign, graphic display panel and highway radio in selecting and presenting the information most relevant to the location of the facility. The process must be automatic and takes into account the severity or impact of the incident and relevance of traffic at signboard location and incident location.

Operation monitoring signals are sent back from all the terminal equipment to the ITIS Centre and the operation of roadside facilities will be constantly monitored at the Centre.

a) Variable Message Sign

Variable message sign provides information in the character format. It has three operation modes. When it is in the automatic mode, the message to be displayed on the board will be automatically composed by a display data server based on the traffic information collected either automatically or manually and stored in the database. Information on congestion normally experienced can be displayed automatically. When it is in the semi-automatic mode, a message is automatically composed but must be confirmed by the operator before it is displayed on the board. Semi-automatic mode is usually applied to messages that have large impacts on the users so that confirmation is required. When it is in the manual mode, any kind of information input by operator through the console can be displayed on the variable message sign. Full-face dot-matrix two-colour LED type signboard is recommended for its flexibility, legibility and operation cost.

b) Graphic Display Board

Graphic display board shows a simplified road network permanently on the board and congestion information at each road section in different colour according to the level of congestion. For example, lamp is off at section without congestion, in orange at section with light congestion, and in red at section with heavy congestion. In addition, location of accident may be marked on the map. Although the type and amount of information that a graphic display board can provide are limited, the congestion information given is easy to understand by any user.

c) *Travel Time Information Board*

Travel time information board provides estimated travel time from the location of signboard to certain selected key locations. It schematically shows the road and major destinations along the road. Travel time estimated by the system is displayed beside these destinations. The travel time is estimated based on the traffic condition gathered by the collection system and display is updated periodically, say every five minutes.

d) *Highway Radio*

Highway radio is a small power radio station installed along a road section. It continuously and repeatedly provides traffic information at the frequency specially assigned to it. The power is so small that only vehicles running along the road can receive and listen to the radio. Thus different information can be provided at different location using the same wave frequency. Information provided at each location can be tailored to the needs of the drivers at the section. Information to be provided is composed by one of the computers in the centre and converted to voice message using pre-recorded phrases. The message is then sent to the roadside transmitter for broadcasting through leaky coaxial cable. To provide a complete message to driver running along the road section with highway radio broadcasting facility, the cable must be laid for about 2km for toll road and 500m for other roads.

Message signs are installed upstream (500 m to 1km) from the broadcasting facility informing drivers the frequency to tune in for the information. Signs are also posted at the starting point of the broadcasting, at the mid-section of the broadcasting and at the ending point of the broadcasting.

9.4.4 Location of Roadside Facility

The roadside facilities described above will be installed at the location according to guidelines shown in the table below. *Figure 9.4.2* shows the location of the existing and proposed variable message sign and *Figure 9.4.3* shows the location of the proposed graphic display panel, travel time display and highway radio.

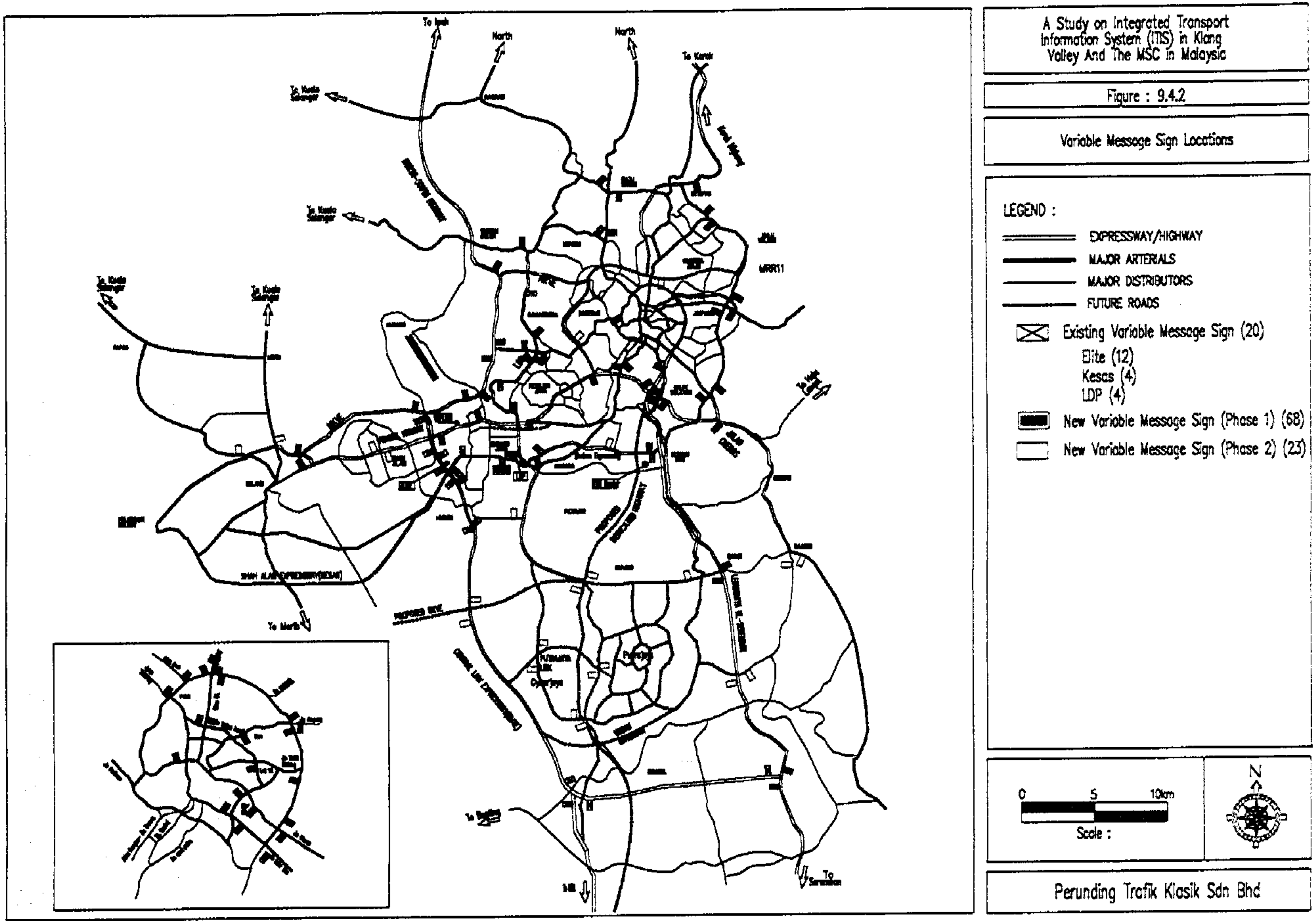

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Figure : 9.4.2

Variable Message Sign Locations

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Figure : 9.4.3

Graphic Display, Travel Time Display and Highway Radio Locations

LEGEND :

- EXPRESSWAY/HIGHWAY
- MAJOR ARTERIALS
- MAJOR DISTRIBUTORS
- FUTURE ROADS
- Graphic Display Panel (10) (Phase 1: 8) (Phase 2: 2)
- Travel Time Display (3)
- Highway Radio (14) (Phase 1: 9) (Phase 2: 5)

Scale : 0 5 10km

N

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Table 9.4.1 Roadside Facility Deployment Guidelines

Device	Toll road and highway	Arterial road
Variable message sign (VMS)	• Upstream of system IC • Upstream of major IC	• Approach to major intersection • Selection point of alternative routes • Entrance to major interchange
Graphic display board (GDP)	• Key location in network	NA
Travel time display (TTD)	• Along radial toll road and highway with high traffic volume	NA
Highway radio	• Along radial toll road with high traffic volume	• Along arterial street with high traffic volume and alignment suitable for highway radio

9.4.5 Car Navigation System

Information dissemination to in-vehicle car navigation unit, which is gaining popularity in several countries, is envisaged in Phase 2. There are two types of route guidance system used by car navigation unit. Static route guidance type provides drivers with the recommended route that is determined by average travel time pre-installed in the system. Dynamic route guidance type receives real-time traffic information from a service centre and then computes the shortest route based on the received information.

Both types of car navigation unit use GPS signal to locate the vehicle location. But GPS signal contains purposeful errors, which can be adjusted if a land based station sending differential signal is available. Moreover, some car navigation devices use gyro and accelerator to improve the accuracy.

Basically there are two method of sending navigation data to vehicles, through FM sub-carrier and roadside beacon. FM sub-carrier uses sub-carrier of commercial FM broadcasting. There is an international standard for sub-carrier data transmission called Data Radio Channel (DARC) specified by the International Telecommunication Union (ITU). It uses carrier at 76MHz and data are sent at a rate of 16kbps. As transmission error detection mechanism is adopted, the effective data transmission speed is 6.83kbps. Character and graphic data can be sent over the sub-carrier. Several FM broadcasting stations in Malaysia have already been using this technology.

FM sub-carrier data transmission can cover a range of 10km to 50km radius depending on the output power of FM station. Thus one station is considered sufficient for the study area.

Roadside beacon type system uses roadside beacons to communicate with vehicles in the vicinity of the beacon. Different data can be sent at each beacon but a large number of beacons are required to cover the study area. Use of roadside beacon type may be considered in the future.

9.5 Transmission System

Traffic information system consists of the centre equipment such as computers, wall map display, transmission equipment placed at the ITIS centre and terminal equipment such as vehicle detector, TV camera and several kinds of signboards. Data, voice and image are exchanged among these facilities through the transmission system. Because the location of terminal equipment is scattered over the coverage area, design of efficient transmission system is critical in terms of initial investment and operating costs. Requirements for the transmission system by various facilities are summarised in Table 9.5.1 and the proposed communication system architecture is illustrated in *Figure 9.5.1*.

The proposed ITIS network will utilise a mix of digital and analogue leased circuits from telecommunication operators. Use of the existing transmission system facilities owned by the toll road operator and installing self-owned cable network may be exploited to find out the most suitable transmission system in terms of technical requirements, initial and operating costs, reliability, security, future expansion and other factors. Moreover, multiplexing of channels at intermediate point needs to be considered to reduce the overall installation and operation costs. In this basic design, however, leased line in a star network is assumed for simplicity and time constraint.

Acquisition of traffic information shall be primarily obtained from the following sources:

- Television (TV) Cameras
- Vehicle Detectors
- Car Parking Information Systems
- Public Transportation Information System
- Other existing traffic monitoring centres (e.g., of DBKL, privatised highway concessionaires, etc)

TV cameras and LAN-to-LAN (local area networks) connections shall utilise digital circuits of E1 (2Mbps) bandwidth in a star network configuration.

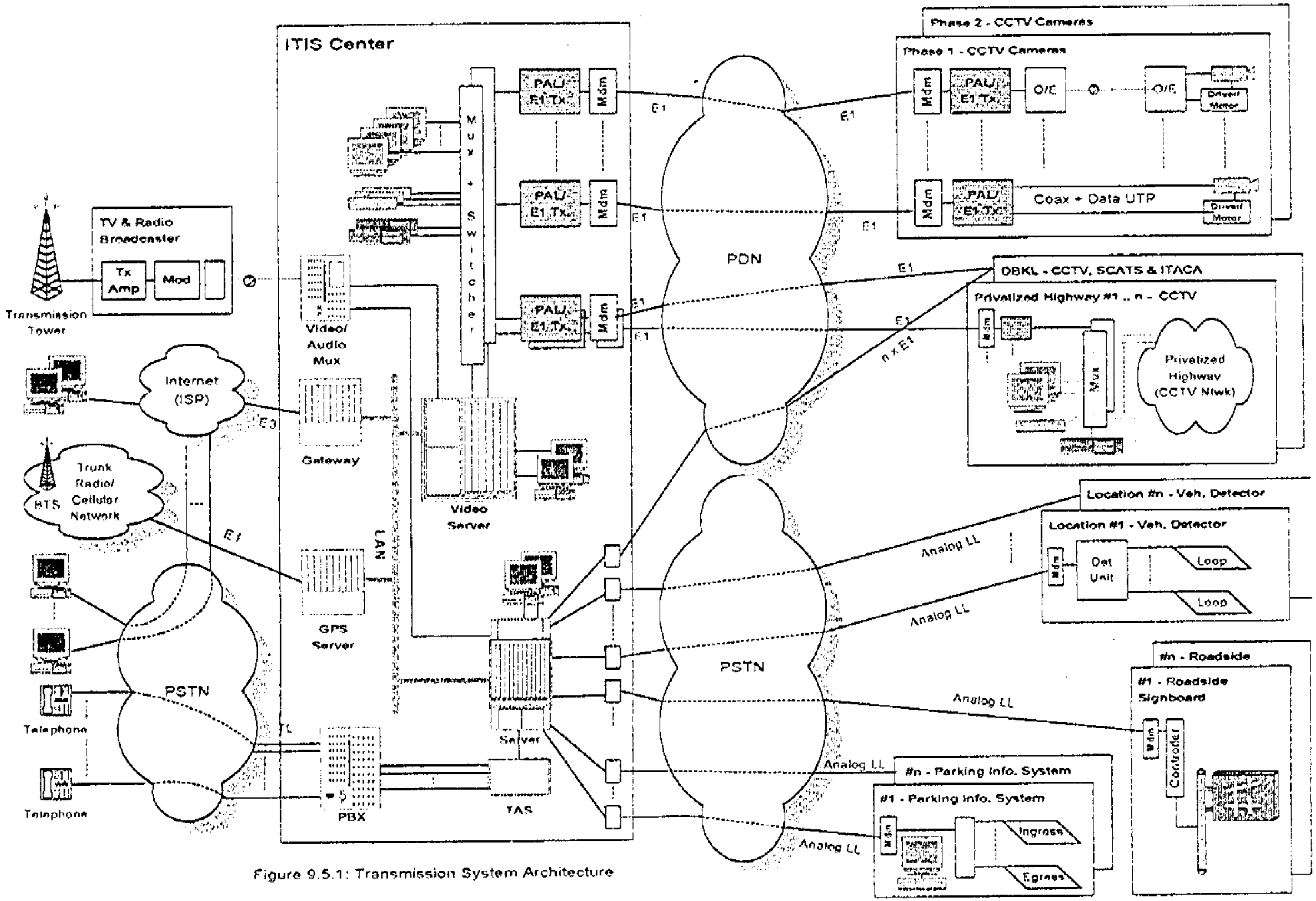

Figure 9.5.1: Transmission System Architecture

TV cameras connected at E1 rate typically offer between 15 to 25 frames per second depending on the resolution desired/selected. There is no discernible flickering of images at such an operating frame rate.

LAN-to-LAN connections will primarily be utilised for internetworking with other computer systems in remote "traffic monitoring centres" to exchange traffic congestion information (e.g., with toll road operators, SCATS and ITACA system) for data integration and processing purposes at the proposed ITIS Centre.

Vehicle detectors and car parking information system will only be connected via analogue leased lines back to the ITIS Centre as the data transmitted is relatively low (i.e., typically less than 9.6kbps required).

The dissemination of traffic information will be channelled through the following media:

- Roadside signboards (e.g., variable message signs, graphic display panels, travel time displays, parking information displays)
- Public TV & radio broadcast (including highway radio)
- Computer dial-up modem/leased circuit connection into an Internet Web site
- Telephone dial-up into an interactive automatic telephone service (ATS)

All roadside signboard will be connected via analogue leased lines due to the relatively low data communication rates required.

Information disseminated via TV and radio broadcast will be transmitted via digital video/audio transmissions to relevant broadcasters (e.g., RTM, AMPS, THR, etc). This will serve as a public service to motorists interested in both pre-trip and en-route information. Certain stretches of highways will be specially fitted with "highway radio" that have "limited distance" radio transmission reach (approximately 50m radius) that can only be picked up by motorists using that particular stretch of highway.

The public may also gain access to traffic information via the use of personal computers by dialling into the relevant Web site hosted by an Internet Service Provider (e.g., JARING or TMNET). The public can also call into a hunting-line number to access an interactive automatic telephone service (ATS) that will play automatically updated audible streams of traffic congestion reports.

Table 9.5.1 Transmission System Requirements

Equipment	Data transmitted	Direction	Analogue/digital	Circuit	Remarks
Information collection					
Vehicle detector	Detection signal	Terminal → Centre	Analogue	Telephone grade line	≤ 2400 baud
TV camera	Video signal	Terminal → Centre	Analogue/digital	Depends on the transmission method	Many variations available including compression
	Control signal	Terminal ← Centre	Analogue	Telephone grade	≤ 2400 baud
Data exchange with other systems	Traffic condition VMS monitoring	Centre ←→ Centre	Digital	Dedicated telephone grade, ISDN or data transmission line	
	Video signal	Centre ←→ Centre	Digital	Data transmission line	
Information dissemination					
Internet	Various traffic related information	Centre ←→ User	Digital	Telephone/ISDN	Provided by telephone company
Cable TV		Centre → Operator	Analogue	Video channel	Provided by cable TV company
Variable message sign	Display control signal	Terminal ← Centre	Analogue	Telephone grade line	HDLC or similar protocol used
Graphic panel display	(congestion, travel time				≤ 9600 baud
Travel time display	and other information)				
	Operation monitoring	Terminal → Centre	Analogue	Telephone grade line	≤ 2400 baud
Highway radio	Congestion and other voice message	Terminal ← Centre	Analogue	Telephone grade line	
	Operation monitoring	Terminal → Centre	Analogue	Telephone grade line	≤ 2400 baud

9.6 Cost Estimate

Cost of the proposed integrated traffic information system project is estimated by examining the costs for three different components of the project; namely engineering services, system construction, and operation and maintenance. It must be noted that the project cost presented here is only a rough estimate meant to be an indication on the size of project. There are still many variable factors such as system functions, type of equipment and its specification, transmission system adopted, import tax and duties, etc. that can affect the final project cost. System cost estimate presented here therefore may fluctuate about 20% up or downwards. All costs are calculated at Year 1999 prices. Foreign currency exchange rate is assumed as RM1.00 = Japanese Yen 33.

As presented in Chapter 8: Conceptual Planning and Design of an ITIS in Klang Valley, the system will be constructed in two phases. The cost estimates are prepared for Phase 1 and Phase 2 separately.

9.6.1 Cost of Engineering Services

Engineering services are required throughout the project period. These services include detailed design of the system including tender document preparation, assistance in contractor selection, and construction supervision and acceptance testing. A detailed design of the system which specifies the kind, quantity, location, function, etc. of the system, equipment and computer software, and method of construction is necessary before the construction contractor is selected through a competitive tender. It is assumed that a foreign consulting firm shall be invited to undertake the design work as integrated traffic information system is relatively new to this country and local consultant who is capable of the detailed design is very limited. The appointed foreign consulting firm is however required to associate with local consulting firm to avail of the local resources and promote technology transfer.

After the detailed design, a competitive tender will be held to select a contractor. During the tender process, which includes pre-qualification, tender announcement, tender conference, tender submission, tender evaluation, and contract negotiation, assistance by a competent consulting firm is also required, particularly in evaluating the technical proposals from tenderers.

In order to ensure the required functions of the system, good quality of workmanship, and timely completion of the project, construction supervision is important and needed. Engineering service by a consulting firm, who has both technical and project management capability will be engaged during the system construction period.

The total engineering service cost for carrying out detailed design, contractor selection and construction supervision is estimated at RM26.7Million and RM15.9Million for Phase 1 system and Phase 2 system, respectively.

9.6.2 System Construction Cost

The system construction cost comprises the cost of equipment, cost of installation, cost in software development, and database preparation. Equipment cost is estimated by referring to the market price of such equipment cost in similar projects, and information from the equipment supplier. Installation work cost is estimated based on information on cost of equipment installation locally gathered by the study team.

In addition to the equipment and service comprising the system, the cost of constructing a new ITIS Centre building and associated works is estimated based on the space and equipment requirements described in Chapter 8.

A good project management is essential for the successful and timely completion of the project. There are other requirements for the project. The costs of project management, acceptance testing, documentation, training of system operator and supply of spare parts are separately estimated.

Many of the equipment are expected to be imported from abroad but some of them may be procured locally. Depending on the country of origin, equipment cost is estimated either in Japanese Yen or Malaysian Ringgit (RM). Installation work cost is estimated in local currency.

Import duties are levied on the imported equipment. The amount varies depending on the classification of equipment ranging from 5% to 30%. For this cost estimate, average import duty of 10% is assumed uniformly. Value added tax of 5% is applied to all cost items.

Table 9.6.1 Summary of System Construction Cost

Item	Amount	(RM-Million)
	Phase 1	Phase 2
Information collection system	132.1	80.0
Vehicle detector system	(119.7)	(70.5)
TV camera system	(12.5)	(9.5)
Information dissemination system	78.5	26.6
Variable message sign	(61.9)	(20.9)
Graphic display panel	(8.6)	(2.2)
Travel time display	(1.5)	-
Highway radio	(6.5)	(3.6)
ITIS Centre system	127.8	105.1
ITIS Centre building	9.2	-
General requirements	37.4	24.3
Import tax and duties	27.0	17.5
Price escalation and contingency	26.5	15.8
Value added tax (5 %)	21.9	13.5
Ground Total	460.4	282.8

9.6.3 Operation and Maintenance Cost

Once the system is completed and put into operation, cost is incurred to operate and maintain the system. Operation and maintenance cost is a recurrent expenditure to operate the system and keep it in a good operating condition.

Operation cost consists mainly of staff (technical, administrative and others), electricity (control centre and outside equipment), lease fee of transmission circuits, communication, vehicle, consumable and other expenses. The annual operation cost shown below is relatively higher than other costs due to the fact that, 75% of the operation cost is the lease fee of transmission circuit. We believe however that this operation cost can be lowered through negotiation with the Telco for a discounted rate on lease fees on the transmission lines.

It is assumed that a maintenance contract will be arranged with a maintenance contractor. The contract price will cover all the costs that will be incurred to provide preventive and corrective maintenance work including maintenance staff (engineer, technician, labourer, driver), depreciation of maintenance equipment and tools, maintenance vehicles, office, communication, etc. Minor modification of the system, such as relocation of terminal equipment due to construction of new road will be carried out under the maintenance contract. But the work will be paid separately. The cost estimate below, however, includes these minor works.

Spare parts are required to replace defective unit or device damaged by traffic accident. Spare parts will be provided by the client out of the stock that will be purchased together with the system construction, or paid separately from the maintenance contract based on the quotation by the contractor. Annual spare part cost is the cost of spare parts that are purchased to replenish the stock and assumed as 3% of the total equipment cost. We have assumed that damage to parts due to vandalism will be minimum.

Operation and maintenance costs are estimated as annual cost and summarised in Table 9.6.2 below. The cost is about 5.1% of the system construction cost.

Table 9.6.2 Annual Operation, Maintenance and Spare Parts Cost

Item	Annual Cost (RM-Million)	
	Phase 1	Phase 2
Operation	12.3	13.3
Maintenance	2.4	3.1
Spare parts	7.0	11.6
Total	**21.7**	**28.0**

9.6.4 Annual Cash Flow

Annual cash flow required to design, construct, operate and maintain the system is summarised in the table below. The flow assumes that the project will start in Year 2000 with the detailed design of the system. The Phase 1 system will become operational in the latter half of Year 2003 and Phase 2 system in Year 2006.

Table 9.6.3 Annual Cash Flow

(Million RM)

Year after completion of Phase I		Detailed Design/ Tendering		Project Supervision		System Construction		Annual O & M	Total Cost
		Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2		
	2000	6.0							6.0
	2001	10.1							10.1
	2002			7.0		280.0			287.0
	2003		6.4	3.6		180.4		10.9	201.3
1	2004		2.0		3.0		110.0	21.7	136.7
2	2005				4.5		172.9	21.7	199.1
3	2006							28.0	28.0
4	2007							28.0	28.0
5	2008							28.0	28.0
6	2009							28.0	28.0
7	2010							28.0	28.0
8	2011							28.0	28.0
9	2012							28.0	28.0
10	2013							28.0	28.0
Total		**16.1**	**8.4**	**10.6**	**7.5**	**460.4**	**282.9**	**278.3**	**1,064.2**

9.6.5 Fund Sources

The proposed ITIS system requires a large amount of fund to construct. In addition, operation and maintenance of the system needs annual budget to keep the system running in good condition. Integrated Traffic Information System is a social system aimed at improving the efficiency of road traffic and eventually the quality of life in the project area. It brings about various benefits as presented in the next section not only to road users, but also road administrator and general public. Some benefits like saving in travel time is obvious although for each driver the amount would be small and not clearly noticeable. Other benefits like improvement of air quality or promotion of information technology are intangible but have large impact on the society as a whole.

For these reasons, it deems appropriate that the construction cost of the system is provided by the public sector as a government project, for example. Use of Official Development Assistance (ODA) may be considered as a source of fund. The required amount is not small but compared with the construction of new highway in urban area, which amounts to RM30Million per kilometre, the project cost for Phase 1 is equivalent to constructing only 15kilometre of the new road, or 25kilometre for the two phases in total.

Even if the construction cost is covered by public fund, it is desirable from the public expenditure point of view, that the operation and maintenance costs or a portion of which be covered by fees collected from users of the system in order to sustain the project. Collection of fee from the en-route drivers is technically difficult. But there are various means to collect fees from the pre-trip traveller information System. Some examples are described below.

Telephone Inquiry
There is a fee collection service offered by Telecom Malaysia using 1-600 prefix number. Using this service, fee can be collected from the users by Telecom Malaysia together with their monthly telephone bill. It is assumed that 1.5 million vehicles are in the project area in Year 2003 when the first phase becomes operational, and 40 % of them are willing to pay for traffic information. The figure of 40% is derived from the results of the opinion survey in which 40 % of respondents have replied that they are willing to pay for the traffic information. It is further assumed that 20 % of those who are willing to pay make telephone inquiry twice a day or about 40 calls a month and RM0.10 is charged for each call. The total annual revenue is estimated at RM5.76 Million.

Internet
A traffic information web site will be operated by the ITIS Centre and a small fee can be charged to users to access and get traffic information. Such a fee will be collected by the Internet Service Providers (ISP) in addition to the monthly or yearly subscription fee of the ISP service. Based on the same assumptions for telephone inquiry, and assuming 20 % of those who are willing to pay have access to Internet, the total annual revenue will be RM 5.76 Million if a monthly subscription fee of RM 4.0 for access to the traffic information web site is assumed.

Car Navigation System
Introduction of a car navigation system is proposed in Phase 2 of the project. The system broadcasts real-time traffic information through commercial FM station using sub-carrier multiplexing. In-vehicle car navigation unit, which will be sold as a commercial product like car stereo, is required to receive the real-time traffic information in the car. A royalty may be added to the price of car navigation unit to recover partially the cost of constructing and operating car navigation system as is the case of the car navigation system in Japan. Manufacturers of car navigation unit in Japan pay fixed amount per car navigation unit sold to the quasi-government non-profit organisation that constructs and operates car navigation system. Navigation unit also requires digital road map recorded on CD-ROM or DVD to display the traffic information over a road map. Developing digital road map is a lengthy and complex work requiring certain capital investment. It is worth considering that basic digital map be developed by the public sector as one of the basic national geographic information infrastructures. The cost of converting the basic digital map into the road map suitable for car navigation system and adding additional features to the map must be covered by the cost of digital road map.

Other potential sources of revenue include charged traffic channel on cable TV, advertisement on web site and cable TV, direct data delivery to taxi and cargo forwarder, etc.

9.7 Expected Benefits from the Proposed Integrated Traffic Information System

9.7.1 Type of Benefits

The proposed integrated traffic information system in Klang Valley and MSC can be expected to produce significant benefits. Among them, time saving brought about by the efficient use of the existing road network will be the biggest benefit. Other benefits include improved traffic safety, reduced adverse environmental impacts by traffic, and enhanced comfort and reliability in vehicular travel.

Like many other information-related systems, benefits of these integrated traffic information systems are wide ranging in nature including many indirect benefits. Moreover, many of these benefits, both direct and indirect are in fact difficult to quantify. Improved overall traffic safety, improved travel comfort, better confidence among road users are some examples of indirect benefits that are indeed very difficult to quantify. Not only the road users and road administrators will benefit from the proposed system, but the general public will benefit from it as well.

Nevertheless, some of the direct and indirect benefits that can be expected from the implementation of the integrated traffic information system are listed below.

a) Direct Benefits to Road Users

- The integrated traffic information helps users to plan their trip better, avoiding congested road sections or changing their travel plan to reduce travel time,
- Drivers on the road are given up-to-minute traffic information and this helps them to detour around the congestion, resulting in savings of travel time cost and vehicle operating cost,
- Incident information helps drivers to take precautions in advance when approaching the accident spot, thus preventing any secondary accident,
- Travel time becomes more predictable and drivers will not be frustrated nor become ruthless as they are always informed of the traffic conditions,
- The improved safety level on the roads enable the users to enjoy safer and more comfortable rides on the roads,
- Reduced travel time by freight vehicles means less transport cost to the transporter and thus cheaper prices of items for general consumers.

b) Indirect Benefits to Road Users

- Users will indirectly benefit from increased work productivity when they can arrive at destinations faster and less stressed out,
- For businesspersons, improved reliability of road transport means improved punctuality to attend their appointments, which in turn means improved client relationship and thus higher performance in business.

c) Direct Benefits to Road Administrator

- Improved traffic surveillance capability that enables early detection of incidents on the road network,
- Traffic-related data such as volume and congestion data provides the necessary basis for planning future road network development and implementing traffic management measures,
- The system provides automatic logging and record of various traffic management measures and operations,
- The improved services on the toll roads would encourage higher utilization of them and thus produce higher toll revenue.

d) *Indirect Benefits to Road Administrator*

- Improved image of road administrator and operator among the road users and the general public on its capability to efficiently manage the road network,
- Improved level of technical knowledge, traffic management skills among the management staff of the operator,
- Better traffic management performance, through which the system can build up better confidence and thus respect from the users towards the management authority and hence users are more likely to obey any traffic management measures implemented by the authority in future.

e) *Benefits to the General Public*

- Improved utilisation of toll roads and arterial roads means less disturbance to local streets from diverted traffic,
- Better traffic flow on the road network means less pollution and thus improved general urban environment for all residents,
- The general economy of the country can benefit with better energy utilisation level and improved overall productivity of citizens.
- Used of cutting edge information technology contributes the promotion of information and communication society.

9.7.2 Estimate of Direct Benefits from Savings on Travel Time Cost and Vehicle Operating Costs

An attempt is made here to estimate the amount of direct benefits to road users due to improved efficiency. Only savings in vehicle operating costs and travel time costs of drivers and passengers, which can be expressed in monetary terms, are considered. Bear in mind that other qualitative and indirect benefits have not been included in this exercise. To estimate the amount of benefits accrued from savings in vehicle operating cost and travel time cost, a macroscopic approach is taken by assuming a specific group of benefiting vehicles under a general traffic environment rather than calculating the cost saving by individual vehicles under different situations. The procedure in estimating these benefits is shown in *Figure 9.7.1*. The base year of the estimate is set at Year 2000.

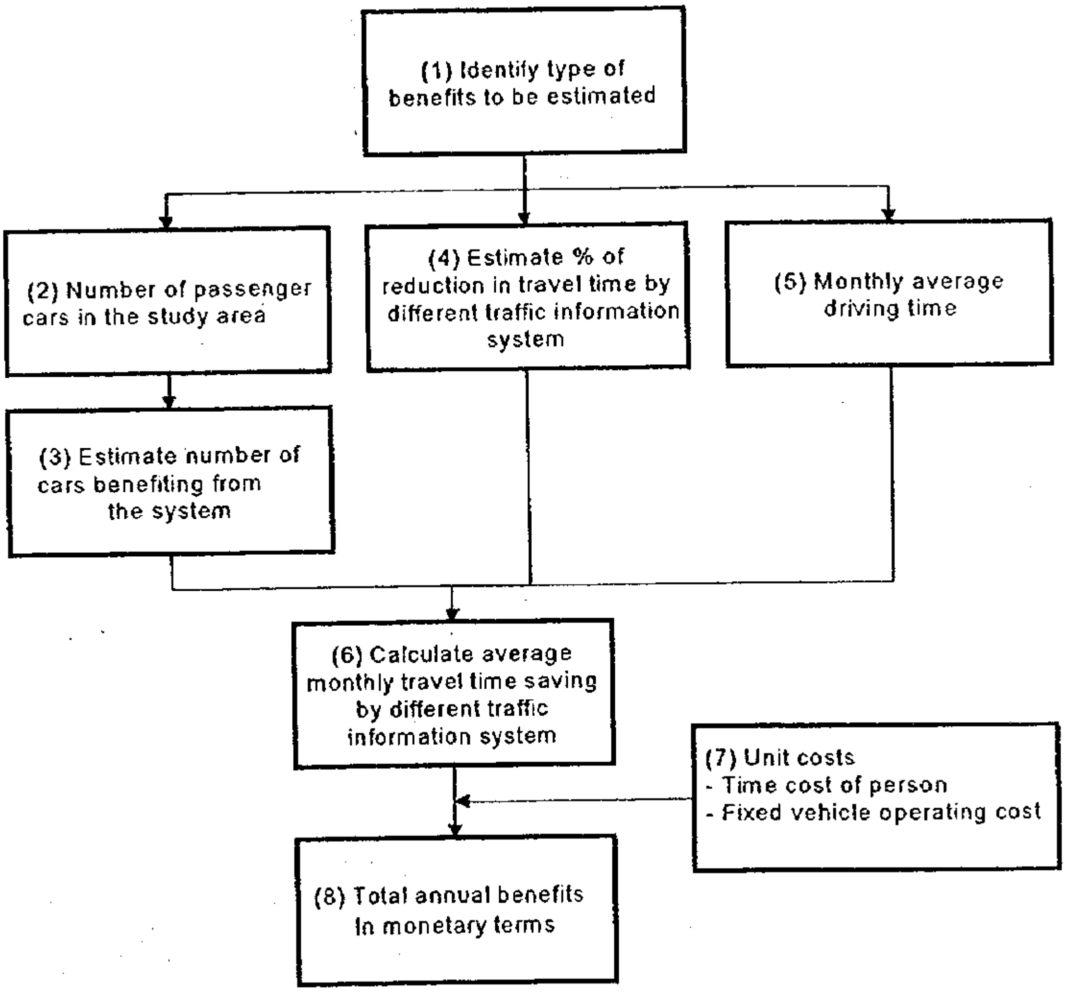

Figure 9.7.1 Flow of Benefits Estimation Procedure

a) *Type of benefits*

Several benefits brought about by pre-trip traveller information system and en-route driver information system are identified in the preceding section. Among them, only travel-time savings derived from the en-route driver information system is considered in this estimate. The reason is that other benefits such as those produced by pre-trip traveller information are difficult to quantify since the size of the user groups is not clear and there is no other reliable reference data to base on.

Among the various types of vehicle and types of trip, only business trip made by passenger car is considered. The reason is that saving in passenger time is most meaningful for business trips, which consists of home-based work trips and non-home based business trips.

Effects of en-route driver information system on other types of vehicles like truck, bus, motorcycle are also sizeable but they are more difficult to quantify regardless of their trip purpose so that these vehicles are excluded from the calculation at this time.

Various media is proposed for disseminating en-route driver information. It is virtually impossible to segregate and measure the effects of each type of information dissemination device. Instead, the following three cases are considered mainly due to the availability of reference data:

Case 1	:	Roadside facilities (variable message sign, graphic display panel, travel time display and highway radio).
Case 2	:	In-vehicle car navigation unit with real-time traffic congestion information in addition to roadside facilities as in Case 1.
Case 3	:	In-vehicle car navigation unit with dynamic route guidance system (DRGS) in addition to those in Case 2.

The Case 1 is the basic case in which only roadside facilities are utilised. The use of in-vehicle car navigation units is added to the use of roadside facilities for information dissemination in Case 2. These units receive real-time traffic information and display it on the monitor screens in the vehicles. Selection of route however is left to the discretion of the drivers. In Case 3, the dynamic route guidance function based on the real-time traffic information is added to the car navigation unit. This function can be performed either by central computer or by in-vehicle car navigation unit. The Phase 1 system described in the preceding sections corresponds with the Case 1 situation here while the Phase 2 system is equivalent to the Case 2 situation. Phase 2 system can also correspond to the Case 3 situation if the in-vehicle units can provide the DRGS function. For the purpose of estimating the system benefits, Case 3 situation shall be used for Phase 2 system.

b) *Number of registered vehicle*

SMURT Study has estimated the number of passenger cars in Klang Valley for Year 1997 as 787,746 units. With a population of 3,774Million in Klang Valley, the car ownership rate works out to be 208 cars/1000 person.

Passenger cars registered with the JPJ in Kuala Lumpur and State of Selangor in Year 1993 was 783,855 units. By 1998 the total registered cars has increased to 1,473,413 units. This represents an average growth rate of about 13% a year. Due to the economic turmoil of 1997 and 1998, annual growth rate has slowed considerably but this rate is expected to increase as soon as the economy recovers. The total number of passenger car for the Study Area is projected to increase with a 'S' curve manner to the Year 2020 as shown in *Figure 9.7.2.* The passenger car population is estimated to increase up to a level of about 2.5Million units by Year 2013 and tapers off at about 2.6Million when a saturation level is reached. By Year 2020, the Study Area is estimated to have about 2.673Million units of passenger car, representing an ownership of about 384 cars/1000 persons. Passenger cars in the Study Area is about 50% of all registered vehicle types but as the country advances toward a developed economy, this ratio is expected to increase to about 70% (In 1998, passenger cars has a 70% share of total vehicles in Tokyo Metropolitan area). Using this ratio as a benchmark, the future vehicle ownership in the Study Area in Year 2020 will be about 548 vehicles/1000 person, which is a level comparable to those in most developed countries. (The rate is 516 vehicles/1000 person in Tokyo Metropolitan area in Year 1998).

Passenger cars in the Study Area are projected to increase from 0.787Million units in 1997 to 0.982 Million units by Year 2000 and 2.384 Million units by Year 2010.

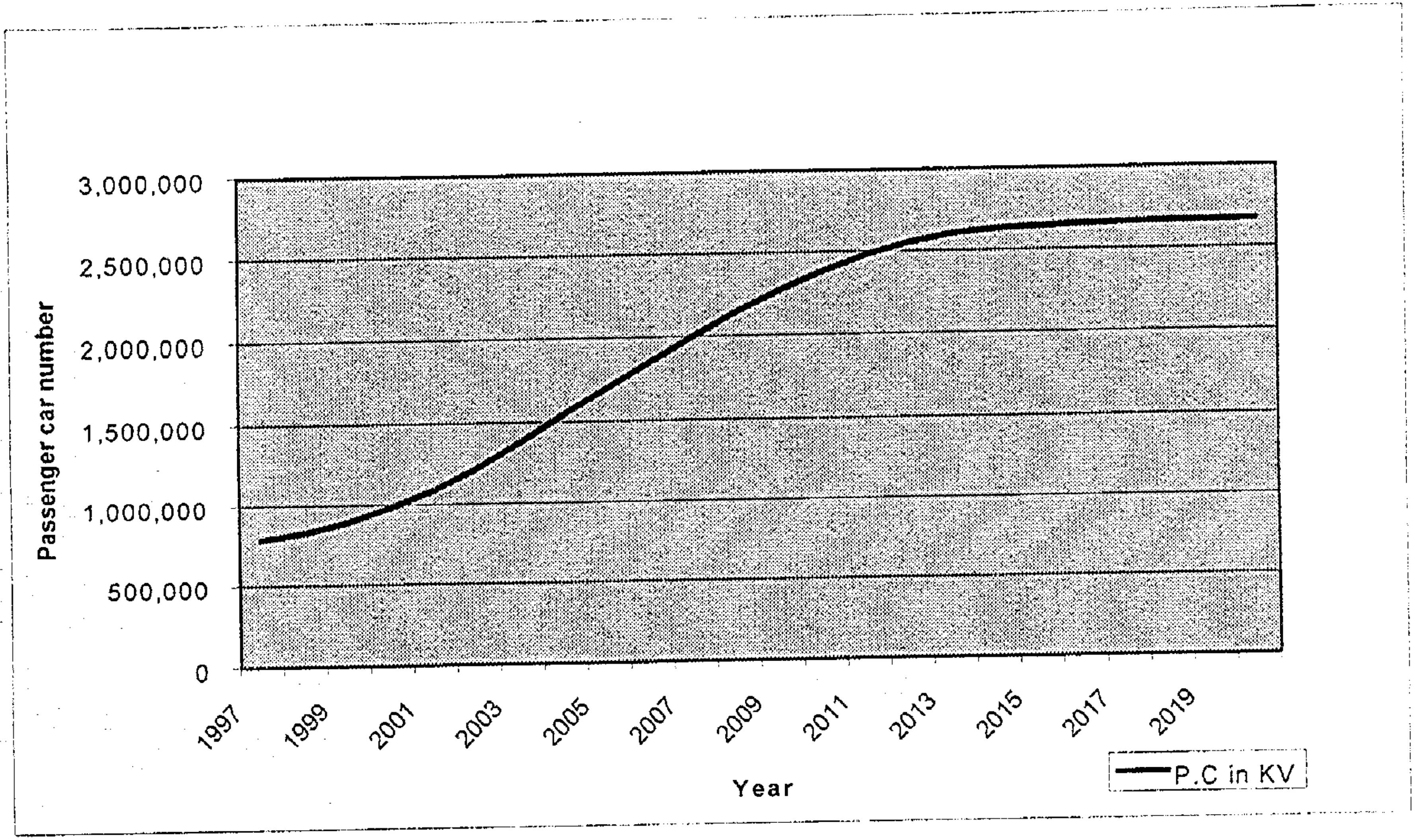

Figure 9.7.2: Passenger Car Growth Trend for Klang Valley Year 1997 to Year 2020

c) *Number of vehicle benefiting from en-route traffic information system*

Not all the passenger cars estimated above will make use of the en-route traffic information system. Only those vehicles passing by the roadside facilities can receive traffic information given by the system and portion of them can benefit from the information. It is arbitrarily assumed that 30% of the passenger cars will benefits from the ITIS in Phase 1 and 40% in Phase 2.

Benefits derived from the car navigation units depend on the number of cars fitted with such units. In this study, the rate of in-vehicle unit installation as experienced and estimated in Japan is applied. A 2.5 cumulative percent of total passenger cars were found to be fitted with the in-vehicle units at the second year of the system operation. By the 10th year, almost a quarter of all passenger cars are expected to benefit from the service. These percentages are however for cars using the static route guidance service. For the dynamic route guidance service, 15% of those passenger cars fitted with the in-vehicle units are assumed to use such a service (based on data referred from VICS centre, Japan)

Table 9.7.1 Percent of passenger cars fitted with in-vehicle units

Year of Operation	Percent * (%)	Year of Operation	Percent* (%)
1st	0.8	6th	12.3
2nd	2.5	7th	15.1
3rd	4.5	8th	18.1
4th	6.9	9th	21.2
5th	9.5	10th	24.3

** percent to total passenger cars*
** source: VICS Centre, Japan*

Thus the following assumptions are made on the percentages of vehicles that would utilise the en-route traffic information and would benefit from the system.

Table 9.7.2 Percent of Vehicles Utilising Traffic Information

Group	Type	Size of Beneficiary
1	Vehicles that receive traffic information through roadside facilities	30 % of total estimated passenger cars in Phase 1 and 40% in Phase 2
2	Vehicles with car navigation system but without DRGS	From 0.8 % (1st year) to 24.3% (10th year) of total estimated passenger cars
3	Vehicles with car navigation system and DRGS	15 % of the above

d) *Percent of travel time reduction*

There is very limited data on actual measurement of benefits derived from en-route traffic information system. We refer to the results of an experiment that was conducted in Japan to estimate the benefits of en-route traffic information system, which was reported in a journal published by the Institute of Urban Traffic Research of Japan. Although the focus of the experiments was the dynamic route guidance function of car navigation system, it also provides data for the effects of other types of traffic information system. In the experiment, four user groups with different route selection method were tested. They have to travel between a set of origin and destination according to the following route selection rules:

- Group A : driven by veteran taxi drivers who are familiar with the traffic condition of the experiment area according to their knowledge and experience,
- Group B : drivers select the route based on the congestion map shown on the car navigation units,
- Group C : takes the shortest distance route suggested by static route guidance (SRG) system where traffic congestion information is not utilised,
- Group D : follows the route suggested by dynamic route guidance (DRG) system, which took into account real-time traffic information.

In the experiment, the average travel time of each group was compared. It was found that the average travel time of Group B (congestion map on car navigation units) was 3.9% shorter than that of Group A (veteran taxi drivers). The average travel time of Group D (route guidance with real-time information) is 5.4% better than Group A. The average travel time of Group C (shortest route regardless of congestion) is in fact 0.5% longer than Group A. It must be noted that the average time saving above is an aggregate result under various traffic conditions including travel during off peak hours.

Using the results of this experiment described above as reference, we assume the travel time saving effect of the integrated traffic information system by the different facilities as shown in the table below.

Table 9.7.3 Percent of Travel Time Reduction Assumed

Type of system	Percent of travel time reduction (%)
Roadside facilities	2.0
In-vehicle navigation unit	4.0
In-vehicle navigation unit with DRG	5.0

e) Average monthly driving hours

Monthly average driving time was obtained based on the results of the opinion survey conducted during this study. It is estimated that drivers in the Study Area spend an average of 38.9 hours a month on the road. Although this value will increase in future, for the estimation purpose however, we just assume a fixed value throughout.

f) Unit time cost and vehicle operating cost

JICA SMURT-KL study, which was completed in March 1999, adopts the following unit person time cost and vehicle operation costs by Year 2000. The time cost of person was computed from the forecasted GRDP and estimated future employment for Year 2000.

Table 9.7.4 Time Cost and Vehicle Operating Costs in year 2000

Item	Cost (RM)
Time cost of person	RM23.2/hour
Fixed vehicle operating cost of passenger car	RM10.1/vehicle-hour

The fixed vehicle operating cost of passenger car was found to be RM10.1/veh.hour by the SMURT study in Year 1997. Again the time value and fixed v.o.c will increase in future as the country develops. However, for this exercise, we just assume fixed values at RM23.2/hour and RM10.1/veh.hour.

The same study also reports that the average occupancy of passenger car is 1.47 persons. The ratio of passenger cars used for business trips is 0.56.

g) Estimated annual travel time savings

For the purpose of estimating the benefits derived from travel time saving, the proposed ITIS project is assumed to begin operation by the middle of Year 2003. Thus Phase 1 will starts to offer services by middle of Year 2003 but car navigation system will only be operational by Year 2006 at Phase 2. Travel-time savings due to roadside facilities are computed from the year the system commences operation that is from Year 2003 for a system life span of 10.5 years. In addition to the benefits from roadside facilities, benefits from car navigation function will be added from Year 2006.

Applying the travel time reduction percentage in (d) and average monthly driving time in (e) above to the appropriate portion of the total estimated passenger car units in Year 2000 as assumed in (c), the annual travel time savings in the study area is calculated as shown below.

A travel time saving of 3.89 million hours is expected in the year 2003 when the system operates for six month. An annual travel time saving of 4.33 million hours is expected in the first full year of the system operation. By the tenth year, a total of 20.18 million hours in travel time saving to passenger cars can be expected from the proposed system.

Table 9.7.5 Annual Travel Time Reduction

Year	Travel Time Saving		Total Time Saving in million hours
	Saving derived from roadside facility function (mil. hours)	Saving derived from car navigation function (mil. hours)	
0	3.89	0	3.89
1	4.33	0	4.33
2	4.76	0	4.76
3	6.92	0.33	7.25
4	7.48	1.11	8.59
5	8.00	2.14	10.14
6	8.48	3.47	11.95
7	8.90	5.02	13.93
8	9.26	6.76	16.02
9	9.54	8.55	18.09
10	9.73	10.45	20.18

h) Total benefits

Using the time saving in item (g) and unit cost data in item (f), annual benefit by travel time reduction is calculated as shown below. The traveller time saving is computed for business trips only, which was set at a ratio of 0.56 of total passenger car trips in the SMURT Study. Vehicle time saving is applied to all passenger cars benefiting from the system. Consequently, by the first year of operation, a benefit of RM126.4Million is estimated to have produced through travel time saving. By the tenth year, an estimated annual saving of RM589.3 Million can be expected from the system.

Table 9.7.6 **Annual Benefit by Travel Time Savings**

Year	Benefit from Travel Time Saving		Total Benefits (RM - Million)
	Benefits by saving in travel time cost (RM - Million)	Benefits by saving in car operating cost (RM - Million)	
0	36.92	19.52	56.44
1	82.70	43.73	126.43
2	90.97	48.11	139.08
3	138.49	73.24	211.73
4	163.98	86.72	250.70
5	193.60	102.39	295.99
6	228.30	120.73	349.03
7	265.96	140.65	406.61
8	306.00	161.83	467.83
9	345.46	182.70	528.16
10	385.47	203.85	589.32
Total	**2,237.86**	**1,183.48**	**3,421.33**

Based on the estimated cost of engineering service, system construction, operation and maintenance in Section 9.6 Cost Estimate, the amount of benefits shown above, and project implementation schedule presented in the next section, an economic internal rate of return of the project is calculated at 14.1% assuming the annual discount rate of 12%.

9.8 Implementation Schedule

A tentative schedule of project implementation is shown in Table 9.8.1 assuming that the project is to be implemented in a shortest time. In order to realise the system, fund must be secured first of all. The duration for this activity is difficult to estimate but it is expected that six to eight months are necessary. Then a consultant team will be selected to undertake the detailed design and tender preparation. These works are expected to take a year to complete. Contractor for the supply and installation of the system will be selected through an international competitive bidding, which needs six months from the pre-qualification to the contract award. The construction of the system itself is expected to take one and half year after the commencement of the work. If the project is initiated before the end of year 1999, the system will become operational in the middle of year 2003, about three and half years after the start.

The activities for Phase 2 system must start while the Phase 1 system is still under construction for the second phase system to be operational in 2006. The same process as Phase 1 system will be taken with shorter duration due to the less amount of work involved in Phase 2.

In the meantime, the Malaysian Traffic Information Authority will be established to manage the system and ITIS building will be constructed where all the central equipment will be placed.

Table 9.8.1 Implementation Schedule