TPDM Volume 10 Chapter 1 – Introduction

1.1 References

1 **Maunsell Consultants Asia**, *Comprehensive Traffic Surveillance and Control Study, Main Repor*t, **1980**.

2 **Hyder Consulting**, *Consultancy Study on the Provision, Management and Operation of Traffic Control and Surveillance Facilities for the Strategic Road Network*, **1999**.

3 **Transport Department**, *Intelligent Transport Systems (ITS) Strategy review*, **2001**

1.2 Abbreviations used throughout Volume 10

AID	- Automatic incident detection
CCTV	- Closed circuit television
ET	- Emergency telephone
ITS	- Intelligent Transport System
LCS	- Lane control signal
SEC	- Speed Enforcement Camera
SRN	- Strategic Road Network
TCS	- Traffic control and surveillance
TCC	- Traffic Control Centre
TD	- Transport Department
TMIC	- Traffic Management & Information Centre
VIP	- Video image processing
VMS	- Variable message signs
VSLS	- Variable speed limit signs

1.3 Purpose and Background

1.3.1 Purpose

1.3.1.1 ***Incidents, recurrent congestion and non-recurrent congestion*** occurring on high capacity trunk roads are likely to result in serious consequences in respect of ***safety and economic loss***. Recurrent congestion at certain periods of time on certain sections of the road network results from the usual pattern of traffic flow, whereas non-recurrent traffic congestion is the result from incidents, special events, inclement weather condition or road works. Due to the importance of the ***Strategic Road Network (SRN)***, maintaining smooth traffic flow on the SRN is one of the key objectives of the Government.

1.3.1.2 The "Consultancy Study on the Provision, Management and Operation of Traffic Control and Surveillance Facilities for the Strategic Road Network" (SRN TCS Study), completed in 1999, confirmed the need for, and traffic benefits of, the provision of large-scale Traffic Control and Surveillance (TCS) facilities on high capacity trunk roads with limited frontage access, classified as the Strategic Road Network (SRN). A detailed description of the SRN is given in Chapter 2 of this Volume. The Intelligent Transport Systems (ITS) Strategy Review, completed in 2001, recommended ***better use of information and telecommunication technologies in traffic management to enhance the efficiency and safety of the transport system***. It also formulated a blueprint for the development of ***ITS*** in Hong Kong and the provision of ***TCS facilities on the SRN*** was considered one of the key components of the Strategy.

1.3.1.3 The purpose of this Volume is to provide planners and engineers with concepts and guidelines in the provision of traffic control and surveillance (TCS) facilities on the road network in Hong Kong. Provision of TCS facilities will facilitate:

- quick and efficient recovery from incidents;
- continuous monitoring and enhancement of traffic flow under the impact of roadworks, other special events or inclement weather condition;
- providing information to motorists about special traffic condition and for traffic diversion in case of congestion;
- reducing the chance of secondary incident, for instance at the queue end of an incident or traffic jam; and
- collecting the traffic condition data for record and planning purposes.

Therefore, the ultimate objectives of a TCS system are to increase the efficiency of the road, improve journey time reliability, enhance road safety, reduce driver frustration, and reduce air-pollution caused by road traffic.

1.3.1.4 Whilst every effort has been made to include the functional requirements of most subjects relevant to the design and provision of traffic control and surveillance facilities based on the most recent information available, research and development of these subjects occur at a rapid pace, and planners/designers of TCS systems should ***keep an open mind on the advancement of technology*** and be prepared to consider the adoption of new technology and practice that prove to be more cost-effective, bearing in mind the need to ***ensure reliability, compatibility and the long-term implications*** such as operation, maintenance and the consequence of failure.

1.3.1.5 The facilities described in this volume generally apply to the open highway sections of the SRN, while special requirements for control and surveillance facilities inside tunnel areas and control room features are the subject of Volume 11.

1.3.2 Background

1.3.2.1 Experience in the developed and developing countries shows that it is unlikely that the road network can entirely satisfy the desires of the population to enjoy freely the benefits of highway travel. Such experience, abroad and in Hong Kong, indicates that unrestrained demand will, at some times and places, exceed the highway capacity and that incidents will cause local congestion and delay. The extreme shortage of land in Hong Kong, with its high density urban development and limited space for roads, can be expected to exacerbate this, despite the relatively low car ownership and high use of public transport in the Territory.

1.3.2.2 The SRN warrants special attention in terms of TCS because of the following reasons:

- It typically carries larger volume of traffic than arterial streets and hence has a significant impact on the mobility of people and goods.
- Because of the high speed of travel, accidents could result in serious consequences. In addition, traffic queue building up, together with the on-coming high speed traffic, say at 70 km/hr or above, could result in serious secondary incidents.
- The SRN typically caters for longer trips and hence has a bigger impact on the trip time.
- Due to the segregated nature of the roadway, it is not easy to find detour during non-recurrent traffic congestion, and the traffic queues would take longer time to clear.

1.3.2.3 The SRN is generally classified into 2 categories. The first category is the Control Areas (primarily tunnels and major bridges) which are provided with dedicated TCS control buildings and each control area is operated by an operator. The remaining SRN sections form the second category and are termed Open SRN sections, for which the Police is responsible for traffic management and enforcement.

1.3.2.4 Following the recommendation of the SRN TCS Study and ITS Strategy Review, Government has decided to establish a Traffic Management and Information Centre (TMIC) as a long-term objective, which will manage the TCS, among other things, of all sections of the Open SRN and will coordinate with the Control Areas to ensure smooth operation of the entire SRN. Prior to the commissioning of the TMIC, a Traffic Control Centre (TCC) will be commissioned by 2004 as an interim measure to perform a similar function, but of lesser scale and scope, as the TMIC. Therefore, ***all future SRN projects will have an interface with the TMIC or TCC with respect to the TCS system. This should be adequately addressed at the planning and design stages through consultation with the Division within TD responsible for the management of TMIC or TCC.***

1.4 Techniques

1.4.1 Surveillance

1.4.1.1 A traffic surveillance system provides the 'eyes' whereby the operating authority can monitor the traffic situation and detect and analyse any disruption. The potential problems caused by congestion and incidents are great. Quick detection and analysis of them is essential if traffic disruption is to be minimised.

1.4.1.2 Surveillance can be performed in a number of different ways. The following are common techniques employed :-

(i) police patrols

(ii) reports from the public

(iii) closed circuit television (CCTV)

(iv) automatic incident detection (AID) equipment

Surveillance facilities will be described in further detail in Chapters 3 and 4.

1.4.2 Control

1.4.2.1 Once congestion or an incident has been located and identified on the SRN, action must be taken to correct the situation in order to minimise its effect on other traffic and to enhance safety for all concerned.

1.4.2.2 The control required will depend, in each case, on the overall traffic situation and the nature of the congestion or incident. The primary measures which can be taken are :-

(i) restriction of traffic joining the SRN,

(ii) restriction of traffic on the mainline,

(iii) speed regulation,

(iv) traffic management and/or diversion,

(v) hazard warning,

(vi) providing relevant information to public transport operators and the public.

Traffic control for SRN will be further described in Chapter 5.

1.5 System Outline

1.5.1 General

1.5.1.1 A TCS system can broadly be visualized as comprising outstation equipment and control centre equipment connected by a transmission network, operated and managed by trained personnel according to pre-set procedures and judgement.

1.5.1.2 ***The TCS system architecture is intended to be as open and modular as possible*** to allow for easy expansion, integration with other sections of SRN, modification or upgrading. ***Proprietary communication protocols of the hardware and software should be given special attention*** in the design and tender stages in order ***to allow the maximum degree of modification in future***.

1.5.2 Outstation Equipment

1.5.2.1 Typical outstation equipment consists of CCTV cameras, vehicle detectors, lane control signals, variable speed limit signs, speed enforcement cameras and variable message signs. Ramp meters controlling the volume of traffic from access ramps into the SRN are generally not provided. For details, please refer to section 5.5 of this Chapter.

1.5.2.2 The processing and storing of data & information can be done locally at the outstation equipment site, or centrally at a designated centre, or both. The present level of technology allows local processing to be carried out at relatively low costs thus minimising the data traffic on the transmission network . On the other hand, the advance of data transmission technology (such as the network management technology) can handle huge data flow at low costs. Under normal circumstances, central processing and storage of data may prove to be more cost-effective, but ***consideration should also be given to the advantage of local processing and storage of information as a safeguard against total loss of data & information*** in case of a transmission failure. Therefore costs vs benefits as well as the consequence of accidental loss of data should be assessed in order to determine the degree of local processing and distributed intelligence.

1.5.3 Control Centre

1.5.3.1 The control centre equipment should consist of the necessary hardware and software with fully integrated control facilities, for interfacing with the outstation equipment. The design of the TMIC is a special subject and not described here. The lesser scale control centres of the Control Areas are described in Volume 11. Section 3.6, 3.7 and 3.8 of Chapter 3 as well as sections 4.4 and 4.5 of Chapter 4 of Volume 10 are also relevant to the planning and design of control centres.

1.5.4 Transmission Network

1.5.4.1 The Open SRN TCS field equipment should be connected to the TMIC, or the interim TCC before the commissioning of the TMIC, through the dedicated SRN backbone optical fibre cable that Government will install in phases under various projects, subject to availability of funds. The backbone cable will follow the alignments of the roads in the SRN shown on Figure 1 included in Chapter 2. The Control Areas (per 1.3.2.3 and 1.3.2.4) shall have their own networks, with linkage to the SRN backbone. Before the completion of the backbone cable, transmission lines will have to be leased from private companies.

1.5.4.2 Other than these networks, in designing a minor transmission system for the field equipment, a dedicated cable network can be built, or circuits rented from private companies, or a combination of both types could be employed. With the advance in technology, ***wireless transmission can also be considered*** provided that its reliability can be proven to be compatible with its function. Site location and condition, their environmental constraints, their recurrent operating and maintenance costs will have to be considered in each case.

1.5.4.3 Power and communication cable ducts installed for a TCS system should comply with the standards specified in Appendix 1 of the Chapter.

1.5.5 Interface with Adjacent Section of SRN

1.5.5.1 In planning and designing any new section of SRN, consideration should be given to the TCS systems of adjacent sections of SRN regarding compatibility and coordination in terms of traffic operation equipment/software maintenance. The Division within TD should be consulted in the early stage of planning to identify and resolve the interface issues.

1.5.6 Technological Development

1.5.6.1 In the design and implementation, it is always necessary to keep abreast of updated technological development, both overseas and at local level. Implementation opportunities should also be carefully assessed. This should include the ***reliability of technology vs the consequence of failure, the life cycle cost implication and staffing requirement, the size of the project, and availability of local agents*** for the equipment. As far as possible and where appropriate, new technologies should be tried out to ascertain their suitability in the local environment before they are adopted for actual implementation.

1.6 Provision of Traffic Control and Surveillance Facilities on the SRN

1.6.1 General

1.6.1.1 It is Transport Department's intention that comprehensive TCS systems should be provided on all existing and new roads in the SRN. Therefore, such provision should be allowed for in the planning stages of various highway projects.

1.6.1.2 The TCS facilities referred to in section 1.5.2.1 should generally be provided on the SRN, with the exception of VSLS which shall be considered only when and where a high traffic volume to capacity (v/c) ratio greater than 1.0 is expected to extend over 5 km of SRN. Emergency telephones (ET) are a standard TCSS feature in tunnel, but not on open highways as local experience has demonstrated that the use of the ETs on open highways was extremely low due to the popularity of mobile phones. ETs already installed on open highways have all been removed in 2003 to save the maintenance and operating costs.

1.6.2 Current Provision

1.6.2.1 Control Areas are currently provided with their own dedicated TCSS to allow the safe and efficient passage of vehicles. The existing SRN outside these areas will in phases be retrofitted with comprehensive TCS systems, whereas all new roads within the SRN will be designed and constructed with TCS systems.

1.6.3 Electrical Installation and Transmission Facilities

1.6.3.1 To allow for the implementation of TCS facilities, TCS cable ducts should be installed for any particular SRN project. Transport Department should be consulted on whether the cables or cable ducts alone for the SRN backbone mentioned in section 1.5.4.1 should also be installed within the project limits. These cable ducts should be laid inside parapets of elevated roads, under verges or hard shoulders. Ducting under the carriageway should be avoided as far as possible. ***For ducting installation standards, please refer to Appendix 1 to this Chapter.***

1.6.3.2 In designing the capacity of the transmission facilities, allowance should be made for possible additional requirements, for instance, arising from the development of traveller information or road tolling. Based on the use of fibre optic for trunk communication, it is recommended that ***three 100mm ducts be provided on each side of the road***, one each for accommodating the backbone cables, local TCS cables between the field equipment and hud and power cables, provided that the designer shall specifically check that this will meet requirements of each individual project.

1.6.3.3 It is currently assumed that fibre optic cables will be used for trunk communication, although the planner/designer should watch out for the technological development regarding other possible mode of transmission such as wireless communication.

1.6.3.4 The field equipment are provided with roadside cabinets for the control of equipment and processing of equipment signals. Typically for the field equipment installed on a gantry structure, the cabinet could be provided one for each equipment or advanced type cabinets that can control all the equipment on the gantry. The designer should select the appropriate cabinet type in consideration of space, equipment type to be controlled and technology. For cabinets located on structures, particularly those with noise barriers, special detailing should be considered for space in accommodating the cabinets.

1.6.3.5 Unless the site conditions do not warrant, the equipment installation should be complete with approproate protection against lighting strikes. The running of the earth cable may require careful coordination with the civil provisions in the design stage.

1.6.3.6 For the efficient transmission of the TCS signals between the field equipment and the control centre, the field equipment signals are normally transmitted, via local TCSS cables, to a roadside communication hub where the signals are concentrated and transmitted to the centre via a backbone cables. Transport Department should be consulted to the provision of the hub building.

App. 1 Ducting Installation Standards

1. For maintenance reason all power and communication cables should be housed in cable ducts. The ducts should generally be 100mm internal diameter U.P.V.C. ducts, while G.I. ducts should be laid 600mm beneath carriageway.

2. Draw/Jointing Chambers (DJC), including draw pits, should be provided:-

   (i) where there is a change in direcion, level or section that could not be permitted for that type of duct;

   (ii) where U.P.V.C. duct would change over to G.I. ducts for crossing the roads;

   (iii) fronting each outstation housing; or

   (iv) at intersection of ducts.

3. To facilitate subsequent communication cable pulling, desirable spacing of draw pits for long and straight ducts should be about 100m, and at closer spacing at curved road sections. As for power cables, there may be special requirements on the drawpit provision, including spacing, and the designer should determine the provision to fit the specific needs or the power company should be consulted where appropriate.

4. To ensure the correct alignment of the duct, a wooden test mandrill can be drawn through the duct as the latter is being laid. On completion of a duct line between any two DJCs or sites of such DJCs, a cylindrical brush connected to a mandrill should be passed twice through the duct to clean the duct and to remove any foreign matter. The wooden test mandrill shall be 250mm in length and 90mm in diameter and the cylindrical cleaning brush shall be 102mm in diamter

5. A hardwood plug or PVC cap should be inserted at the ends of each section of the duct between two DJCs or sites of such DJCs until the whole section has been tested and passed. After the section has been tested and passed, each end should be blocked by a hardwood plug or any other approved means to prevent the ingress of foreign matter.

6. Two 10mm diameter nylon draw wires should be threaded through and left in each section of duct between two DJCs or sites of such DJCs. These nylon wires will be used later for drawing in the cables.

7. Rattan rods should be used to find out the exact location of blockage or damage of a duct and to clear blockage.

2.1 References

1 **Maunsell Consultants Asia**, *Comprehensive Traffic Surveillance and Control Study, Main Report*, **1980**.

2 **Wilbur Smith and Associates**, *Third Comprehensive Transport Study*, **1999**.

3 **Hyder Consulting**, *Consultancy Study on the Provision, Management and Operation of Traffic Control and Surveillance Facilities for the Strategic Road Network*, **1999**.

2.2 Introduction

2.2.1 Background

2.2.1.1 The Strategic Road Network (SRN) was originally identified by the Comprehensive *Traffic Surveillance and Control Study* (CTSCS) as the Segregated Road Network requiring some form of traffic surveillance and control measures for safety and operational purposes. The need for these roads and their alignments were established in the Comprehensive Transport Study (CTS).

2.2.1.2 With the network modified and renamed, the Transport Policy Co-ordinating Committee (TPCC) endorsed the establishment of SRN in June 1984. It also accepted the need for applying some form of enhanced traffic surveillance and control measures on these sections of SRN which have been or will be constructed to high capacity limited access standards.

2.2.1.3 The actual as well as the planned SRN has ever since been expanded. The Third *Comprehensive Transport Study* (CTS-3) and its regular review by Transport Department provides the updated planned network. The need for TCS systems covering the whole SRN and the provision of a centralised management centre, Traffic Management and Information Centre (TMIC) was proposed in the *Consultancy Study on the Provision, Management and Operation of Traffic Control and Surveillance Facilities for the Strategic Road Network* (SRN TCS Study)

2.2.2 Purposes of SRN

2.2.2.1 The establishment of SRN serves a useful purpose in the highway planning process, because provisions for the implementation of traffic control and surveillance facilities on the SRN roads can be allowed for in the early stages of various highway projects.

2.2.2.2 SRN also provides a defined basic network on which traffic control and surveillance facilities could be implemented in stages.

2.3 Criteria for Classification as SRN

2.3.1 Criteria

2.3.1.1 For the inclusion in SRN, the main criteria that a road should satisfy are that it :-

(a) lies on a major traffic corridor for the economic conveyance of people and goods, either defined by policies or evolving from subsequent land development, and

(b) be designed to carry large volumes of free flowing traffic by virtue of its geometric standards, limited frontage access, pedestrian segregation and grade separated interchanges, or

(c) be an important main spur connecting onto the network which could affect the operation of the main line flow.

2.3.2 Other Considerations

2.3.2.1 The effectiveness of the road system being defined as SRN depends on it operating as a network. To achieve this it is necessary to include roads which, although not fully satisfying the above criteria, are main connections between lengths of road that do. The exception to this is where it would be technically more appropriate, in the interests of overall road system management, to bring the connection within the ambit of an area traffic control system.

2.4 Current SRN and Types of Roads

2.4.1 Current SRN

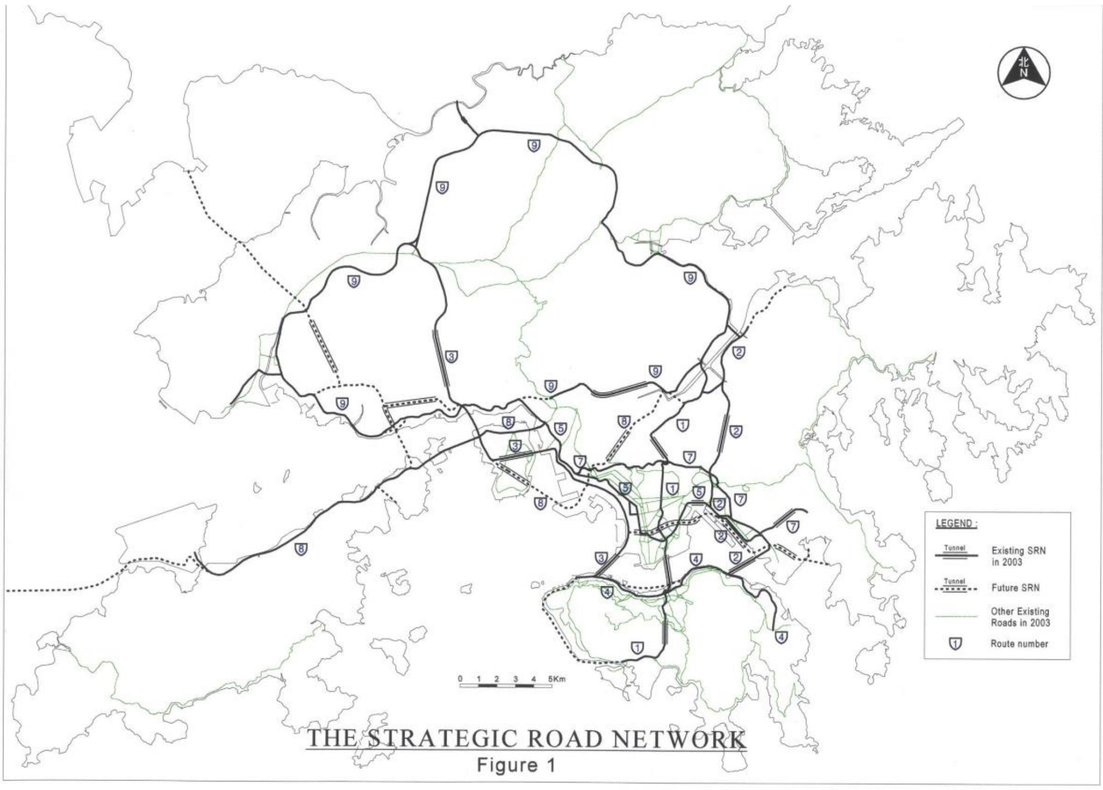
2.4.1.1 SRN is not a fixed network. From time to time, newly identified transport links might be added to this network, or currently planned routes in the network may be deleted or modified. In this respect, SRN requires regular monitoring and periodic revision.

2.4.1.2 The SRN has expanded from about 120 km in 1980 to about 170 km in 2002. By 2011, according to the CTS-3 final model run "Preliminary Traffic Forecasts" the SRN would be expanded to about 300 km. Fig. 1 shows the SRN existing in 2002 and projected up to 2011.

2.4.2 Types of Roads

2.4.2.1 As shown in Fig. 1, SRN consists of both rural and urban trunk roads which are constructed at grade, on structures or through tunnels. It should be noted that some tunnels are under private control and operation, and extensive length of the SRN in the New Territories are classified as Expressways which are designed to high standards and are governed by the Road Traffic (Expressway) Regulations under the Road Traffic Ordinance. It should therefore be noted that different parts of the SRN are subject to different statutory requirements. For instance, the current legislation permits the use of lane control signals only on those roads designated as expressways, within tunnel areas, or other designated areas where specific legislation has been enacted to permit the use of lane control signal. Therefore, attention should be paid to the type of road and the need for legislative amendments when planning the TCS system.

FIG.1 THE STRATEGIC ROAD NETWORK



TPDM Volume 10 Chapter 3 – Closed Circuit Television System

3.1 References

1 **Maunsell Consultants Asia**, Comprehensive *Traffic Surveillance and Control Study, Main Report*, **1980**.

2 **TCSD, Transport Department**, *A Preliminary Study on the Introduction of an Information and Advance Warning System in Hong Kong*, **1989**.

3 **Hyder Consulting**, *Consultancy Study on the Provision, Management and Operation of Traffic Control and Surveillance Facilities for the Strategic Road Network*, **1999**.

3.2 Purposes

3.2.1 Theoretically, CCTV is an ideal facility for incident detection because it provides almost all the information required including the level of traffic disruption, seriousness, location and sometimes the cause of the incident as well. However, to achieve the incident detection objective, operators have to be employed to closely watch all pictures returned from the CCTV cameras. This is a monotonous task which may result in incidents escaping the detection of the CCTV operator, and requires plenty of monitors, space and manpower if the coverage is extensive.

3.2.2 In practice, an Automatic Incident Detection (AID) system is used to alert the operator of the possible occurrence of an incident. The CCTV facility is then used to confirm the incident before further action is initiated at the control centre. CCTV cameras can also be used as detectors of an AID system through video image processing (VIP) technology. Dedicated cameras, separate from the surveillance cameras, are howerver normally used for this purpose. The AID system is a separate subject for discussion in Chapter 4 of this Volume.

3.2.3 Apart from incident detection, CCTV will also provide information relating to the nature and seriousness of the incident so that the appropriate recovery and/or emergency services can be despatched accordingly. It also provides a convenient means for monitoring the development of the traffic disruption caused by the incident. This information is useful in planning for other contingency measures when the situation becomes worse.

3.2.4 The CCTV system can also be employed to serve other useful purposes. The facility provides a useful means for evaluating the effectiveness of a diversion scheme or any new traffic control techniques introduced on the SRN. Traffic surveys can be carried out via the CCTV facility. The system also provides the flexibility of recording the traffic data for subsequent analysis at a convenient time. For the operation of the TCS field equipment, the operators prefer to further confirm the status of lane control signals and variable message signs through the CCTV.

3.3 CCTV System

3.3.1 If the road for which the TCS system is planned is within a Control Area with a specific traffic control centre, Volume 11 provides guidelines on how the CCTVs should be controlled at the control centre. For open SRN sections, the CCTV cameras as well as other parts of the TCS system shall be controlled by the TMIC (or the TCC in the interim), and therefore communication links shall be provided to connect the CCTV system with the TMIC/TCC. These links shall have access to all control facilities provided for the CCTV system. According to the current practice, the CCTV system is also required to be linked with the respective TD Regional Offices, Police and possibly Highways Department. Where there is a boundary crossing involved, Immigration Department may also require CCTV images to be made available to them. Therefore, potentail users of the CCTV system should be consulted in the planning stage to confirm the linkage of the CCTV system

3.3.2 The major components of a CCTV system are listed below.

(a) Camera assembly

(b) Camera support

(c) Camera control

(d) TV monitor

(e) Video recording

(f) Central control and video switching

(g) Picture transmission

The TV monitor, video recording and central control & video switching features are control room facilities that are fully described in Volume 11.

3.4 Camera Assembly

3.4.1 The features and functions of the CCTV cameras change quite rapidly with the advance of technology. The following discussions should be considered as general guidelines on the performance of the CCTV cameras.

3.4.2 The camera shall give satisfactory images of the picture in both daytime and at night. At night and under the normal street lighting conditions in Hong Kong, the camera shall be able to capture satisfactory images, while, at the same time, not producing a significant 'comet tail' effect from moving lights. The images captured by the camera shall be of quality good enough to be discernible to the human eye and for video image processing for AID and other traffic surveillance purposes.

3.4.3 The camera assembly shall be provided with an environmental housing to protect it from the harsh weather conditions commonly found in Hong Kong, e.g. an internal heater to prevent condensation and a sun shield for protection from direct sunlight. For lens cleaning, a windscreen wiper, washer and water container with a pump should be provided.

3.4.4 The designer should check if the camera mounting would be subject to lightning attack. If yes, proper lightning protection system should be provided.

3.4.5 The camera shall be of a type commonly available in the market at the time of installation. As the camera may be used for AID or collecting traffic data through VIP technology, attention should be paid to ensure that the performance standard of the camera will be compatible with such functions.

3.4.6 The handy doom type cameras and web cameras may be considered for special applications.

3.5 Camera Support

3.5.1 The camera is usually mounted on a platform strong enough to withstand and dissipate smoothly the vibration caused by the moving traffic and strong winds. It should be convenient for maintenance access and yet constructible in terms of underground obstructions. The latter factor could be an overriding one for CCTV supports to be constructed in urban SRN.

3.5.2 The CCTV location should allow a clear view of the traffic on the SRN. Presently, a 15m camera height pole is generally used. Greater mounting height generally inproves visual coverage and reduces the number of cameras required but induces greater effect in terms of vibration which is usually amplified by the height of camera support. Other rigid structures such as gantries, overbridges and tall noise barriers should also be considered. Where there is a choice between installing a smaller number of cameras on high masts and installing a larger number of cameras on gantries that also support other equipment, a cost analysis should be carried out to dertermine the more cost-effective alternative.

3.5.3 Building rooftops are particularly suitable for mounting CCTV cameras because they offer panoramic views of the SRN and are not subject to vibration due to traffic or strong winds. For maintenance access, the rooftop camera should be mounted on a retractable bracket if the camera needs to have an outreach for better views of traffic. The constraints are the construction of the riser cable duct and the building owners' permission or high rental. For these reasons, Government or quasi-government buildings are better options.

3.5.4 For high mast type camera support, suitable facilities such as a winch system should be provided for the lowering of the camera assembly for maintenance. Under certain circumstances, cat ladder or bucket trucks may be used for access to cameras mounted on structures such as gantries. Safety, security and cost-effectiveness should be among the major factors to consider in determining the means of access. TD shall be consulted regarding the use cat ladder or bucket trucks.

3.5.5 If there is a chance for the cameras to be used for VIP purposes, even in the longer future if not immediately, particular attention should be paid to the camera support for limiting the amplitude of movement of the camera, which could significantly affect the accuracy of function of the camera for VIP purposes.

3.6 Camera Control

3.6.1 The following camera control facilities are considered necessary for traffic surveillance purposes.

(a) Camera Position :
Pan (left, right and 2 speeds)
Tilt (up, down)

(b) Lens Setting :
Zoom (in, out)
Iris (open, closed)
Manual override for auto-iris
Focus (in, out)

(c) Environmental :
Wiper (on, off)
Heater (on, off)
Washer (on, off)

(d) Camera State :
On/standby (to prolong life)

(e) Pre-set Position :
Capability to store a number of pre-set camera positions

3.7 Picture Transmission

3.7.1 The video transmission system shall be of a modern design making extensive use of the latest technology available. It shall be reliable and be able to provide a good quality picture at the receiving end. Due to the large bandwidth of the video signals, leased lines for their transmission are very costly. Considerations such as installing switchers on sites so as to transmit only the selected CCTV signals and digital transmission should be considered. At the time of updating this Volume of TPDM, digital cameras were being considered to save costs of digital conversion of the CCTV images.

3.7.2 An optical fibre cable network will be installed by Government to provide the backbone for the transmission of the signals of the CCTV systems and other TCS systems of the SRN to the proposed TMIC (or the proposed TCC before the commissioning of the TMIC). For transmission circuits connecting with this backbone cable or with another control centre, a cost-effective and reliable choice shall be made among feasible options such as leased lines from a private company, dedicated lines laid for the project, wireless transmission, etc. Capital costs as well as maintenance costs shall be taken into account when the choice is made.

3.8 Camera Spacing and Location

3.8.1 CCTV cameras shall aim at providing full coverage of the SRN. The camera shall be able to provide a clear image of a reasonably sized object within its field of view. The camera spacing is dependent on various factors like the geometric alignment of the stretch of road, the presence of any obstacle in the vicinity of the camera and the zooming power of the camera lens, etc. In practice, it has been found that most cameras are able to provide a clear image of an object at a distance of 800m assuming that the field of view is clear of obstacles and that the road alignment is straight with no or minimal gradient. Under this situation, ***the adjacent cameras can be spaced at 1 km to 1.5 km*** intervals. To ensure coverage of interchanges, cameras shall be provided at about 150m from the nose of the merging/diverging point.

3.8.2 It is generally rather dificult to site individual cameras perfectly on a map or plan. Experience indicates that a lot of site factors which are not shown on the plans are critical in determining the location of the cameras. Where the cameras are to be installed on an existing road section, it is strongly recommended that site visits be made and photos taken with a tower wagon in determining the camera coverage. It should be noted that in some locations, a small movement even of only 2 metres can have a significant effect on the field of view. For new roads or existing roads to be widened, because the new features would be non-existent, a similar site survey would help but it is more relevant to carry out a detailed CCTV coverage analysis on a plan with all visibility obstructions shown, noise barriers in particular. The designer should take good care of the effects of tight alignments on the CCTV camera views. The use of 3-dimensional computer simulation could be considered in determinig the camera locations.

3.8.3 Various other factors may also need to be considered when deciding on the location of the camera. For example, cameras should be located at the outside of a bend to improve visibility, sites which are prone to accident and would induce damage to the camera equipment should be avoided and sites on structure may be undesirable because of vibration problems, etc. Another consideration in site selection is the ease of maintenance access. Sites, such as the median of the road, that require traffic lane closure for access, are clearly unacceptable as lane closure SRN is a major operation.

3.8.4 In designing the camera locations, designers should take cognizance that there are going to be many cameras in the TMIC. Proliferation of cameras, due to reasons such as mounting cameras on low structures (e.g. gantries) resulting in limited coverage, will certainly hamper the TMIC operators work. Although the objective is to provide full CCTV coverage on the SRN, ***minor blind spots***, if a camera can be saved, would be acceptable subject to the agreement of the Transport Department.

3.8.5 On the other hand, attention should also be paid to special location (e.g a major road intersection with very heavy traffic) which require closer surveillance of the moving traffic. Installation of cameras at such locations should be considered even if it would require the local spacing of the cameras closer than the 1 km. A balance should be struck in determining the total number of CCTV cameras.

4.1 References

1 **Maunsell Consultants Asia**, *Comprehensive Traffic Surveillance and Control Study, Main Report*, **1980**.

2 **TCSD, Transport Department**, *A Preliminary Study on the Introduction of an Information and Advance Warning System in Hong Kong*, **1989**.

3 **Hyder Consulting**, *Consultancy Study on the Provision, Management and Operation of Traffic Control and Surveillance Facilities for the Strategic Road Network*, **1999**.

4.2 General

4.2.1 An incident will usually generate traffic disruption, delay and congestion on the affected road network. On the Strategic Road Network (SRN), the effect is more pronounced because of the higher traffic speed and volume. At an incident spot, a traffic queue could build up fast, and this together with vehicles travelling at 110 km/hr without the knowledge of the queue could result in serious secondary incidents. SRN sections with tight curves are particularly prone to such occurrences. To minimise these adverse impacts, it is desirable that an incident should be detected, action be initiated, and the motorists be warned of hazards and advised of diversion routes as quickly as possible, in order to save life and to minimise delay and congestion to others travelling on the affected section of the SRN.

4.2.2 Incident detection is one of the objectives of the provision of traffic surveillance facilities on the SRN. The CCTV system is one of the means to detect an incident but it is not comprehensive because it would require deployment of a large number of traffic operators to continuously watch the TV monitors. The process is monotonous in nature, often slow for the purpose and may be affected by poor visibility. Other means include police patrol and incident reports from the public. The former requires significant staffing resource and does not ensure quick detection whereas the latter is unreliable and can best be treated as a supplementary source of information.

4.2.3 An automatic incident detection system (AID) is therefore necessary to monitor the traffic continuously and to alert the control room operator in the event when any traffic anomaly is detected. The traffic operator will then make use of the CCTV system to confirm the occurrence of an incident before recovery actions are initiated.

4.2.4 AID is still an art and there are dozens of AID algorithms available commercially but none can detect incidents without false alarms; neither can they detect every true incident. Therefore, the AID system is usually supplemented by a CCTV system. The AID systems are usually quick in detection and can alert the operator of a possible incident automatically, thus making the detection/rescue process more efficient and dispensing with the need of constant human concentration on every part of the SRN continuously.

4.3 Automatic Incident Detection System

4.3.1 The AID system comprises two main components, viz: outstation detector stations and a central computer system.

4.3.2 Detection stations are installed at regular intervals along the SRN. At present, inductive loops are still considered to be the most reliable type of detector for this purpose. These detector stations will monitor the traffic condition continuously and will collect the required traffic parameters including speed (if double loops are provided), occupancy and volume. The data are transmitted back to the central computer at short regular intervals for real-time analysis by the incident detection algorithm.

4.3.3 Above-ground detectors based on visual image, mircro-wave, infra-red light, magnetic imaging, ultra-sound etc. are also used. Owing to the serious disruption to traffic arising from the maintenance work for inductive loops, particularly that resulting from the periodic road surfacing on the SRN, above-ground detectors tend to become more popular and there is intensive development in the technology and products. However, the sensing capability of these products are usually affected by a host of many physical factors, such as the shape and material of objects in the vicinity reflecting the detecting rays, weather condition, natural vibration and other movements of the detectors, etc. These factors may not become obvious during the design stage when the road and the associated infrastructures have not yet been built. It is therefore essential to address these issues adequately during the design stage, when specifying the site acceptance test, and at commissioning.

4.3.4 Transport Department has used or carried out on-site tests on the following types of above-ground detectors:

- Video based
- Micro-wave
- Passive infra-red
- Magnetic imaging.

4.3.5 Based on Transport Department's experience, it has been found that the video based detectors can perform satisfactorily for traffic counting as well as AID when the environment is well lit and good mounting position of about 10m above the road is available. The performance deteriorates under exceptionally adverse environmental effect such as heavy rainstorm or fog, but according to limited test results available at the time of updating this volume, the performance is still acceptable. The technology is developing fast on this type of detector, and it is expected that the environmental effects can be dealt with more effectively as time goes by. Micro-wave detectors have also proved to be effective for the same purposes, but significant problems have been encountered at Tsing Ma Bridge, due to interferences from some unknown source which seems site specific. Successful experience has been had with detectors using passive infra-red emission for vehicle counting but they have not been tried locally for AID purposes. Regarding the magnetic imaging type, no success has been experienced in Hong Kong yet.

4.3.6 For Open SRN sections, the designer of the outstation equipment of the AID system should liaise with the TCS designer/coordinator of TMIC or TCC regarding the characteristics of the detection algorithm to ensure that the design of the outstation equipment and linkage thereof to the TMIC or TCC will be compatible with the adopted algorithm with respect to all the details.

4.4 Detection Algorithms

4.4.1 Incident detection algorithms operate by detecting sudden changes in the traffic pattern brought about by an incident. At present, there are many algorithms in use but none of them are 100% reliable. Development work is still being undertaken by various institutions to improve the performance and especially the reliability of these algorithms.

4.4.2 Based on the loop concept (either the actual inductive loop or above-ground detection system using “virtual loops”), there are broadly two types of incident detection techniques: one to identify incidents during medium to heavy flows and the other during light flows. In the medium to heavy flow situation, the occurrence of an incident will cause a sudden traffic constriction. This will result in a high density shock wave moving upstream from the incident site and a low density shock wave moving downstream. Detection is achieved by recognising these shock waves at the upstream detector station, downstream detector station or both. Traffic density is usually difficult to measure directly but could be derived from other easily obtainable parameters such as volume, occupancy and speed. This type of algorithm appears more appropriate for the traffic situation likely to be encountered on the SRN in Hong Kong. Under light to medium flow situations, shock waves will not normally manifest themselves. One method for detecting incidents is to compare the traffic pattern at one detector station to that at the next detector station downstream and to register any significant change due to a 'lost vehicle'. Another method is to project the passage of each vehicle forward to the next detector station and raise an alarm when a vehicle does not arrive. A lot of research and development work is still being undertaken on these types of algorithm.

4.4.3 There are more advanced algorithm packages that vary the algorithm according to the actual traffic condition, and “Neural Algorithm” that would also constantly monitor the past traffic condition and adjust the algorithm based on past experience. These advanced algorithms should be considered for new installations.

4.4.4 For detectors not based on the loop concept, the algorithm used can be totally different from the above. For instance, some systems based on video image processing would track the continuous movements of vehicles entering into pre-defined zones and signal an incident when there is irregularity recorded, such as vehicles stopping for more than a specified period of time.

4.4.5 For systems based on video imaging processing, be they based on the loop concept or not, errors may occur when the position of the sensor (usually a CCTV camera that is panned or tilted from time to time) deviates from the original orientation after a period of time. The designer shall consider asking for software that includes error detection and warning.

4.5 Design Considerations

4.5.1 The following sections refer to the design considerations on the open highways. For AID under tunnel conditions, reference should be made to Volume 11.

4.5.2 Detection Rate (DR) The DR is the percentage of incidents detected out of the number of true incidents. ***A minimum of 70% DR*** should be aimed at.

4.5.4 Mean Time to Detect (MTTD) It is the average time elapsing between the occurrence of an incident and the algorithm recognising its presence and raising an alarm. Generally, a closer detector spacing will give shorter detection time for systems based on the loop concept. MTTD will have an effect on the standard of the Incident Recovery Service to be provided for the SRN and will be further discussed in Chapter 6 of this Volume. Some AID systems based on VIP report an incident based on the analysis of only the data captured at each individual site and therefore the detection time is not related to the detector spacing. As a rough guide, most algorithms can achieve ***a MTTD of 1 minute under normal traffic volume***. It should be noted however that some algorithms perform a few cycles of 'persistence checks' which enhance the FAR and DR at the expense of the MTTD.

4.5.5 Detection Location Detector stations should not be located at sites where traffic turbulence is a common occurrence as this will have a marked effect on the false alarm probability. Examples of these sites include major entrances and exits on the SRN.

4.5.6 Detector Station Spacing The detector shall cover every lane at the detection point. There is no definite rule for the spacing of the detector stations. For systems based on the loop concept, the closer the detectors are, the shorter is the detection time and the more precise is the incident location but the higher rate of false alarms as the algorithm will be executed more frequently. As a general guide for systems based on the loop concept, the current world-wide standard is to space the ***detectors at 500m intervals***. In an enclosed environment such as tunnels, the spacing requirement could be more stringent.

4.5.7 Execution Rate The higher the frequency at which the algorithm is executed, the shorter will be the response time and the higher will be the false alarm rate and demands on the communications network,Generally, most algorithms employ an ***execution rate of 20 to 30 seconds***.

4.5.8 Whatever detection system and algorithm are used, it is necessary to monitor the accuracy of the system and it may be necessary to carry out calibration and adjust some setting in the system from time to time. This shall be ascertained thoroughly during the design stage, and the calibration and adjustment shall be within the capability of the operating staff without the need to rely on the vendor's expertise on an on-going basis. Tender specifications shall spell out clearly the requirement for the Contractor to provide training and Operation & Maintenance Manual for this purpose.

TPDM Volume 10 Chapter 5 – Traffic Control for SRN

5.1 References

1 **Maunsell Consultants Asia**, Comprehensive Traffic Surveillance and Control Study, Main Report, **1980**.

2 **TCSD, Transport Department**, *A Preliminary Study on the Introduction of an Information and Advance Warning System in Hong Kong,* **1989**.

3 **Hyder Consulting**, *Consultancy Study on the Provision, Management and Operation of Traffic Control and Surveillance Facilities for the Strategic Road Network,* **1999**.

5.2 Introduction

5.2.1 Upon the detection of an incident, the control room operator will initiate a series of control measures advising motorists of the incident ahead and/or directing them to change lane/route prior to arriving at the incident site. The drivers' reaction to these control measures will change the traffic pattern on the affected section of the SRN which will be monitored continuously by the surveillance system. This will enable the control room operator to ensure that adequate measures are taken to deal with the incident. This concept of traffic surveillance and control is illustrated in Figure 5.1.

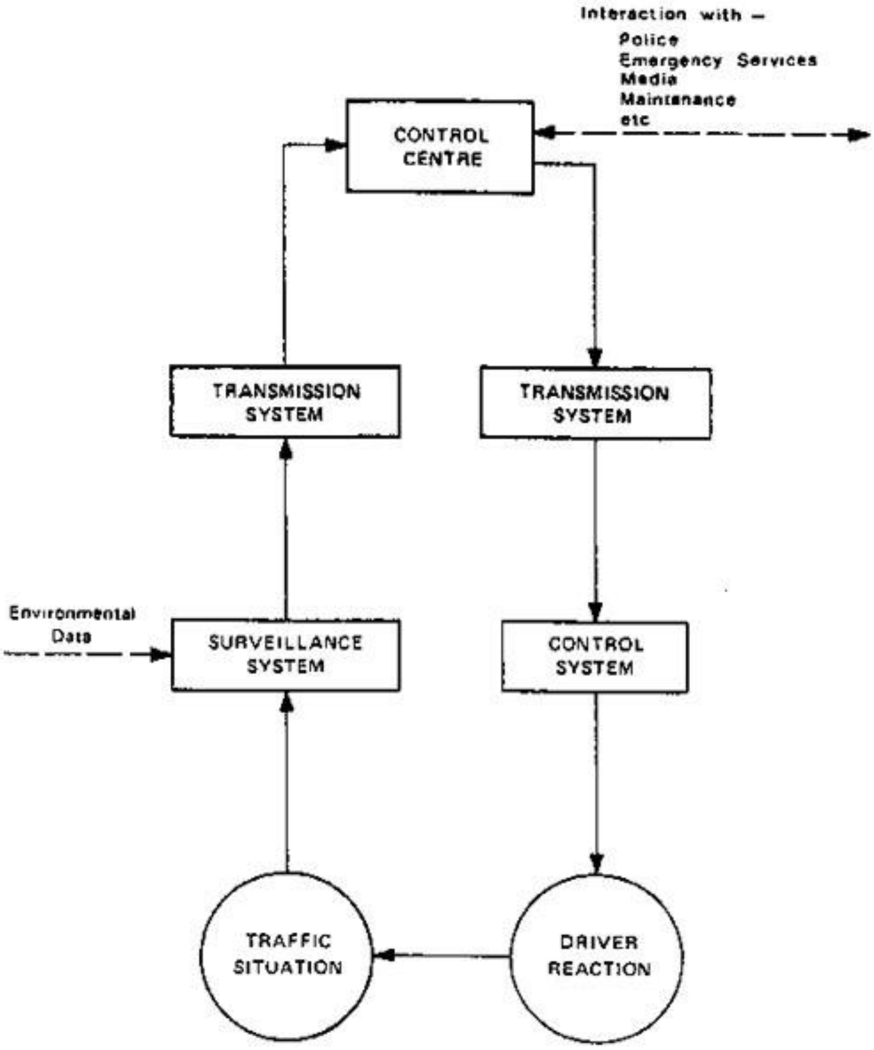
5.2.2 Common incidents on the SRN include traffic accident, vehicle breakdown and out of petrol, debris on road and adverse weather conditions (high wind, heavy rain, low visibility, etc.). Depending on the seriousness of the incident, appropriate control measures may need to be initiated to deal with the incident. The functions of these traffic control measures are to:

- reduce hazards arising from the incident;
- prevent secondary incidents;
- assist the passage of emergency and recovery vehicles;
- reduce congestion and delay; and
- reduce driver frustration and environmental impact due to traffic congestion.

5.2.3 Control measures are also implemented to deal with planned events such as road works and special events. In the absence of an incident, special event or road works, control measures can be implemented under slow and saturated traffic conditions to improve the efficiency of the road network and reduce driver frustration, for instance by displaying journey times or other information on the variable message signs. In the UK, variable speed limit signs are engaged to vary the speed limit automatically in response to traffic volume/speed to optimize the road network efficiency. Variable speed limit signs are currently used in tunnel areas and Tsing Ma Control Area to deal with incidents primarily for traffic safety purposes. Government is planning to introduce these signs to other sections of the SRN, but since the colours of these signs, produced by light emitting diodes, are different from those of the fixed speed limit signs, Government will proceed to amend the relevant subsidiary legislation before operation of these signs on the other sections of the SRN.

5.2.4 For a large bridge, there may be other causes of incident than those mentioned above. These include high wind condition necessitating closure or partial closure of the bridge before any incident occurs, and damage caused to the bridge by a vessel. Closure of all or part of the bridge and diversion of traffic to other routes will be necessary under these scenarios. Where there is a major bridge involved and these scenarios are possible ones, the traffic control facilities shall be designed to take care of these scenarios, e.g. with the use of lane control signals, barriers and variable message signs. The monitoring systems for detecting high wind and structural damage to the bridge are essential design considerations but are outside the scope of the TCS system.

FIGURE 5.1: CONCEPT OF SURVEILLANCE & CONTROL SYSTEM



5.3 Control Strategies and Facilities

5.3.1 To reduce the effect of an incident, different control strategies shall be made available to deal with incidents with varying degrees of seriousness. The following sections describe some commonly used control strategies which need to be considered in the design of a traffic control system for the SRN

5.3.2 Lane closure Minor incidents may require one or more lanes to be closed in the affected section of the SRN. The traffic control system shall provide this facility and the motorists shall be given advance warning of the lane closure and of the need to change lane.

5.3.3 Carriageway closure In the case of an incident which causes complete blockage of the carriageway or if it is advisable to close the mainline to facilitate recovery action, the affected section of the SRN will need to be closed to all traffic. The traffic control system shall allow for the closure of the SRN on a sectional basis. Drivers will need to be informed of the closure and all traffic shall be directed off the SRN at the immediate exit upstream of the closed section. At the same time all entrances to the affected section of the SRN will be closed.

5.3.4 Restrict traffic demand on the SRN (ramp metering) Lane closure as a result of an incident will reduce the traffic capacity of the affected section of the SRN. This will create a bottleneck situation and would inevitably induce congestion and delay to all traffic upstream of the bottleneck. In the event that this congestion becomes intolerable, it will be necessary to restrict the traffic joining the SRN upstream of the incident site. Ramp metering has proven to be effective in maintaining the mainline flow stability. However, in view of the generally short on-ramps in Hong Kong, which have limited reservoir for storing the stopped traffic, this measure has not been implemented in Hong Kong so far.

5.3.5 Exit closure In the event that an incident occurs in close proximity to an exit of the SRN, it may be advisable to close the affected exit on safety grounds. There may also be other operational reasons for closing exits on the SRN and the traffic control system shall make proper allowance for this. In the event that any of the exits are closed, the motorists will need to be informed well in advance of their arrival at the closed exit.

5.3.6 Speed regulation For safety reasons, it is necessary to regulate the speed of the traffic approaching the incident site to a safe level below the normal speed limit allowed on the SRN. Suitable facilities shall be made available in the traffic control system to advise the motorist to slow down to a safe speed when they are approaching the incident site. One of the methods is to use variable speed limit signs. In the UK, variable speed limit signs are engaged to vary the speed limit automatically in response to traffic volume/speed to optimize the road network efficiency. In Hong Kong, the law at present may not permit the operation of variable speed limit signs on open highways (except in designated control areas where specific legislation applies) either on safety or efficiency ground. Legislation amendment is needed to permit such practice. Other methods for slowing down traffic approaching an incident site involve warning signals and informational messages to alert and advise the driver to slow down in advance of a traffic hazard.

5.3.7 Contra-flow operation In situations where an incident causes serious congestion upstream, it may not be possible for the emergency and recovery vehicles to arrive at the incident site quickly. In such circumstances, the traffic control system shall make provision for these vehicles to arrive at the incident site in the contra-flow direction from the next downstream junction. This contra-flow facility shall only be made available for the emergency and recovery vehicles and should only operate under close supervision of the control centre and the police on site, on the section of the carriageway/lane which has been closed temporarily to the normal traffic. This contra-flow arrangement would require lane control signals to be provided on both sides of each supporting gantry. These facilities should be provided only on particular sections of the SRN where there is a genuine need, and shall not be considered as standard features of the TCS system. FSD and Police should be consulted.

5.3.8 Hazard warning For more effective control of traffic, it may be necessary to warn the motorists of the hazard ahead in conjunction with the application of any incident control measures described above. Advance warning of the location of the traffic queue arising from an incident will reduce the chance of queue end collision; information on the nature of the incident and/or the cause of delay will usually alleviate the frustration and anxiety of the motorists who are caught in the congestion. Wig-wag amber lamps as described in section 5.8.5 shall accompany hazard warning signs.

5.3.9 Speed Enforcement Camera (SEC) To facilitate Police in enforcing the speed limit imposed on the SRN, provision of SECs of such type and system design as to enable the enforcement work to be done efficiently should be considered in conjunction with Police.

5.3.10 Transport Information System (TIS) The TIS is being developed by TD at the time of updating this Volume of the TPDM, and will be connected to the TMIC and TCC. Some of the information may be useful for traffic control. Attention should be paid to this when the interface of a section of SRN with the TMIC or TCC is designed. The details of the interface should be worked out together with the Division within TD responsible for the management of the TMIC and TCC.

5.4 Lane Control Signal (LCS)

5.4.1 This facility is used to advise motorists of the following lane status:

- lane open
- lane closed
- lane ahead blocked and change lane as directed

5.4.2 Lane control is achieved by the use of 'lane signals' installed along the mainline and at the entry and exit ramps of the SRN. The current legislation permits the use of lane signals only on those roads designated as expressways or Control Areas where specific legislation applies. It is now considered that lane signals should be provided on the whole SRN including non-expressways, and corresponding legislative amendments are necessary. On open highway, this lane signal is of the matrix type. There shall be one such signal for each lane. The appropriate number of lane signals are mounted on a gantry with each signal placed directly above the centre of its associated lane. Figure 5.2 shows a typical lane signal and the arrangement on the gantry.

5.4.3 The spacing of the LCSs should be considered in conjunction with the associated cost. Closely spaced gantries are more effective for traffic control purpose but gantries are expensive items to fabricate and install. As a guideline, a spacing of **1 km** on open highway should be used for design purpose. In general, the alignment and the geometry of the road section will also need to be considered when deciding on the location of these lane signal gantries. For example, it may be desirable to have signal gantries located at entrances and exits on the SRN. Lane signals should be combined with direction signs and grouped with CCTV/speed cameras, variable message signs and variable speed limit signs as far as possible to save cost and to improve clarity.

5.4.4 LCSs generally have narrow beam widths of 15^o to 30^o. If the siting of LCS on a tight bend is unavoidable, the designer should specify the orientation of the supporting gantry to achieve an optimum view of the LCSs.

5.4.5 A LCS can have four aspects. It shall display a downward green arrow when the lane is open to normal traffic. It shall display a red cross if the lane is closed. An oblique green arrow pointing to the left or right shall be displayed to direct motorists to change to the lane on the left or right hand side respectively because of lane blockage ahead. In the past, it was considered that the LCS at the near-side lane and off-side lanes should have only three aspects because the left- pointing oblique arrow was irrelevant for the near-side lane and so was the right-pointing arrow for the far-side lane. Unless there is no full-width hard shoulder on the road, it is now recommended that the near-side lane should also have four aspects to allow traffic diversion onto the hard shoulder if necessary. Figures 5.2 and 5.3 give examples of the various lane signal aspects. For ease of maintenance and stock keeping, all the LCS should be procured with the 4 aspects. However, for the off-side lane, the LCS should have the keep-right aspect not connected up.

5.4.6 Each lane signal shall have two yellow lamps, one on each side of the signal assembly. These lamps shall be activated to provide a wig-wag flashing indication to attract the attention of the approaching motorists when the lane signal is displaying an oblique green arrow or a red cross. The lamps shall flash alternately at a rate of 60 to 90 cycles per minute.

FIGURE 5.2: LANE SIGNAL

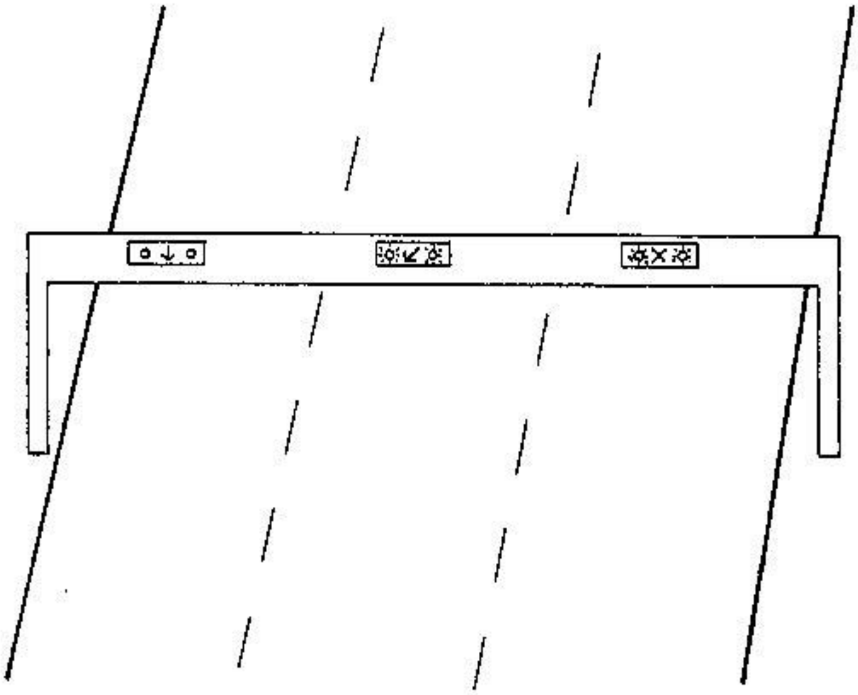
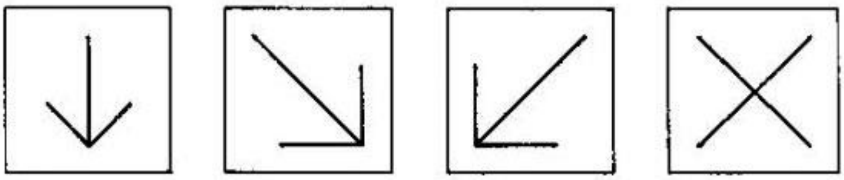


FIGURE 5.3: LANE SIGNAL ASPECTS



5.4.7 In the event of a lane closure, these lane signals shall be activated in a way such that the approaching motorist will see a lane diversion signal (oblique green arrow) first, followed by a lane closure signal (red cross) at the next downstream gantry. All lane signals within the closed section of the lane shall give a red cross indication. This shall include the next lane signal downstream of the incident site, if necessary, after which the normal lane open (downward green arrow) can be displayed. Figure 5.4 gives an illustration of this arrangement.

5.4.8 For closure of the carriageway, it is operationally more convenient to implement at a suitable exit via which traffic can be diverted to the adjacent all-purpose road network. In this situation, all lane signals at the point of mainline closure shall show the 'closed' status (red cross). Those signals for the exit lanes shall continue to show 'open' status (downward green arrow). Approaching motorists shall be advised, by means of an oblique green arrow, to divert to the near side lane for exit. This can be achieved by closing one or two upstream lanes at a time until all traffic are travelling on the near-side lane. Figure 5.5 gives an illustration of this arrangement.

5.4.9 If it is desired to provide contra-flow operation for any section of the SRN, an additional set of lane control signals should be provided for the contra-flow direction. These signals can be mounted back-to-back with those for the normal direction. During contra-flow operation, the contra-flow lane (the off-side lane) should first be closed to traffic in the normal direction by adopting similar procedure for lane closure. After confirmation is obtained from the CCTV system that the contra-flow lane is cleared, then a downward green arrow can be displayed at the required lane signal in the contra-flow direction. **It must be emphasized that contra-flow operation should only be used with the specific and express approval by Transport Department**.

FIGURE 5.4: LANE CLOSURE

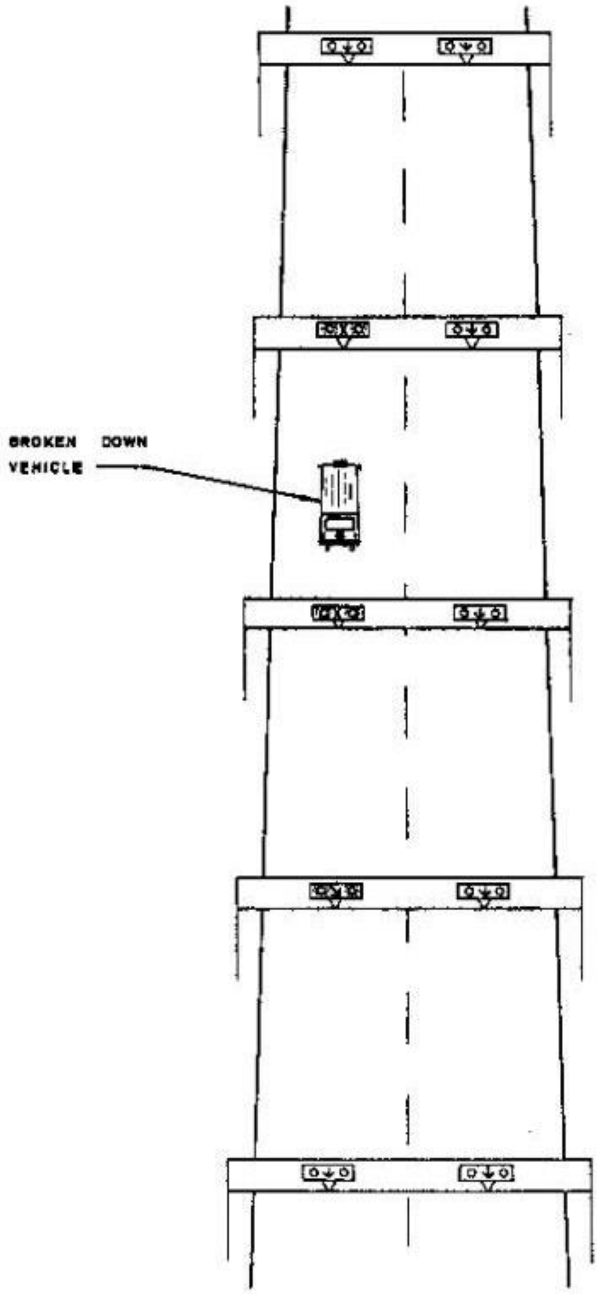
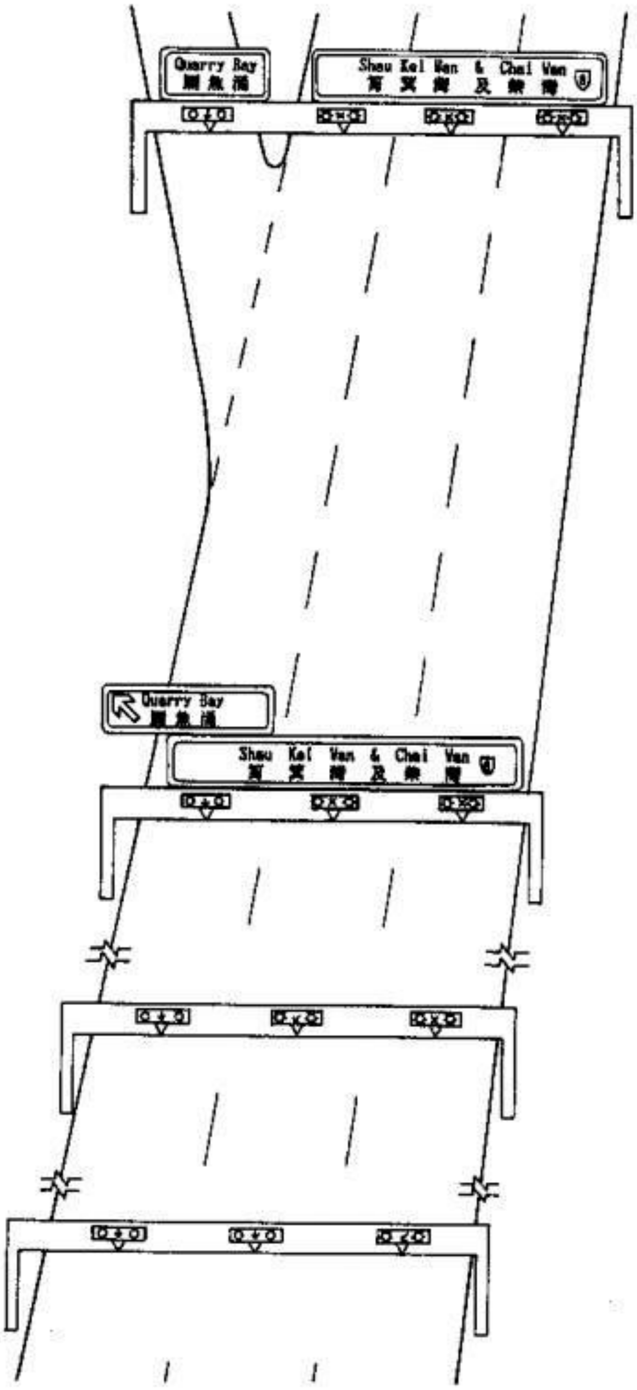


FIGURE 5.5: CARRIAGEWAY CLOSURE



5.5 Entrance Control

5.5.1 An effective way of dealing with congestion on the SRN which may or may not be a result of an incident, is to reduce the traffic demand on the affected section of the SRN. Traffic control at the entrance ramp is a useful facility for this purpose. To regulate the traffic, the entrance ramp may be fully closed or partially closed or the flow may be regulated by using a technique known as 'ramp metering'. However, if the ramp length is short or the traffic is very heavy, the traffic queue may extend backwards and block the adjacent road network, and many ramps in the SRN in Hong Kong are not suitable for ramp metering.

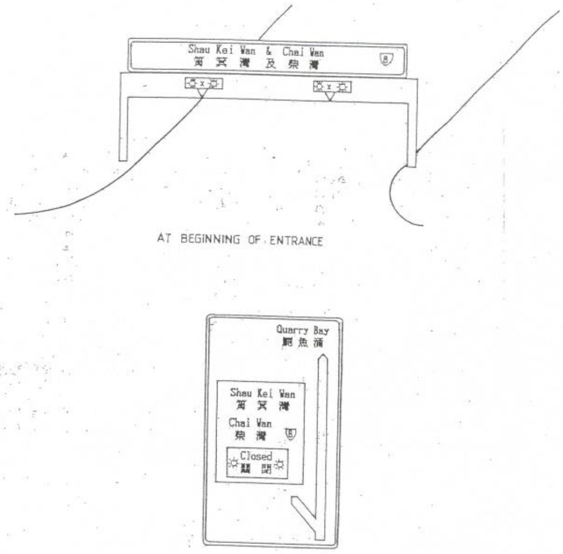
5.5.2 As a general guideline, ramp meters shall not be considered unless the on-ramps are over 250 m long and with traffic flows are under 900 vehicles per hour per lane. In case the length of the on-ramp and the traffic flow qualify for the consideration of ramp meters, the current policy is to make civil provisions for the installation of the ramp meters in future. The provisions may include cross-road ducts, drawpits and space for the installation of the ramp meter controller.

5.5.3 To implement full closure or partial closure of the entrance ramp, a set of lane signals is required to be installed at the start of the entrance ramp. For complete closure of the entrance ramp, the corresponding lane signals shall display a red cross together with flashing yellow lamps indicating that all lanes on the ramp are closed to traffic. In this instance, advance warning shall also be given to the motorists approaching the entrance to the SRN. For this purpose, consideration could be given to the provision of a variable message sign or a secret 'closed' sign incorporated in the directional sign upstream of the entrance where diversion is still possible. The secret sign shall be supplemented by two wig-wag yellow lamps to attract the attention of the motorists. Figure 5.6 illustrates a possible arrangement for complete entrance closure.

5.5.4 Ramp metering is a system designed to control the number of vehicles entering the mainline of the SRN so that its capacity is not exceeded and the flow becomes less turbulent. It is effected by installing traffic signals at the entrance, upstream of the merge with the mainline. The merging traffic is then regulated by controlling the green time of the traffic signal. Different ramp metering techniques are available. A simple one is fixed time control where the green time is pre-programmed according to the time of day. A more complicated real-time metering technique is based on the comparison between the measured flow levels upstream and downstream of the merging point and the green time is made proportional to the spare capacity available in the downstream direction. Other techniques include 'gap acceptance' whereby detectors are installed upstream of the entrance to detect traffic gaps of an acceptable length on the near-side lane of the mainline. These detectors will also collect speed information to allow the arrival time of the gap to be predicted. The traffic signal will show green at an appropriate time to match the arrival of the gap with that of the ramp vehicle.

FIGURE 5.6: ENTRANCE CLOSURE

T.P.D.M.V.10.5



AT BEGINNING OF ENTRANCE

AT LAST POSSIBLE DIVERSION

ENTRANCE CLOSURE

Figure 5.6

5.6 Exit Control

5.6.1 Closure of an exit slip road, should this be required, can be achieved by adopting similar procedures as for lane control. Exit closure is implemented by closing the appropriate exit lane on the mainline. At the exit, lane signals for all lanes on the exit slip road shall display a red cross together with flashing yellow lamps to indicate closure. Advance warning should also be given to the approaching motorists by displaying an oblique green arrow (usually pointing to the right-hand lane) to divert the motorists away from the exit lane(s). Figure 5.7 shows the arrangement for exit closure.

5.6.2 Similar to entrance closure, a variable message sign or a secret 'closed' sign with wig-wag yellow lamps incorporated into the upstream directional sign may be employed to inform motorists of the exit closure.

5.7 Speed Limit Control

5.7.1 In the event of an incident and for safety reasons, it may be necessary to slow down the speed of traffic approaching the incident site. Apart from an incident, a reduced speed limit may be imposed because of adverse weather conditions (e.g. foggy or heavy rain) or traffic congestion on a particular section of the SRN. One of the methods is to use the variable speed limit sign (VSLS). Other methods involve warning signals and informational messages to alert and advise the driver to slow down in advance of a traffic hazard. The law at present may not permit the operation of VSLSs in Hong Kong on open highways (except in designated control areas where specific legislation applies) either on safety or efficiency ground. Transport Departemnt is planning to make legislation amendment to permit such practice.

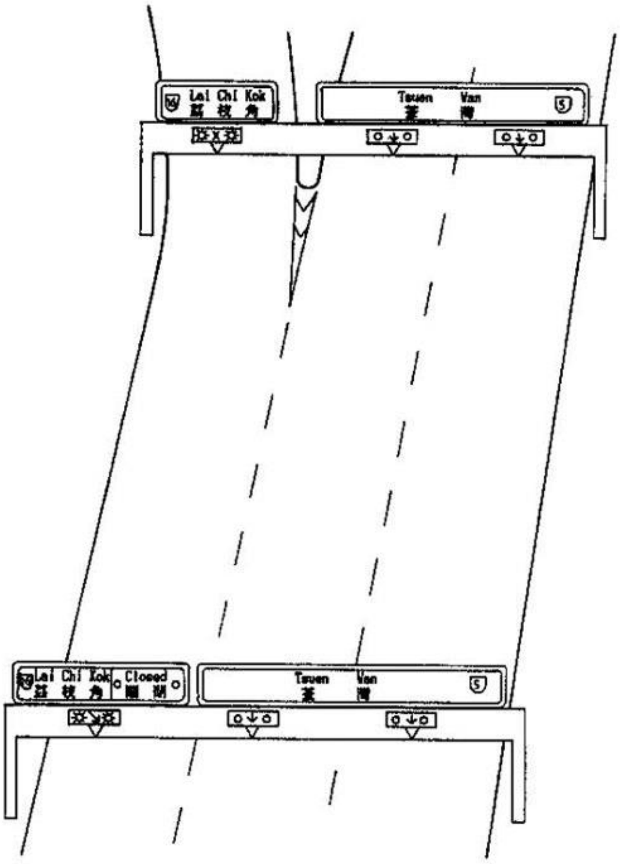
5.7.2 VSLSs are installed in tunnels, within a specifically designated traffic control area (such as Tsing Ma Control Area) for special traffic management. The SRN Study recommended their installation on sections of the SRN which have traffic volume to capacity (v/c) ratio greater than 1.0 over 5 km of carriageway. If it is clearly envisaged (for instance based on the forecast of the traffic impact analysis) that the v/c ratio will exceed 1.0 during the life of a particular proposed section of the SRN, provision shall be made in the design and construction of the road such that VSLSs can be installed without incurring excessive resources or causing excessive traffic disruption in future. The VSLSs can be pole or gantry mounted. Such provision includes the structural adequacy of gantries for taking up the loading arising from the VSLSs, spaces reserved for the signs, ducting reserved for the transmission cables, etc.

5.7.3 The variable speed limit sign should be supplemented by a pair of wig-wag amber lamps which should be activated whenever the speed limit sign is displaying a value below the normal value. Figure 5.8 illustrates the arrangement for variable speed control.

5.7.4 Speed control is relatively less critical compared with other SRN control measures. The spacing and size of the VSLSs shall follow the requirements of section 2.3.2.80 of TPDM Vol. 3. Barring special circumstances restricting visibility, VSLSs should be fixed to the same gantries as lane control signals.

5.7.5 If VSLSs are used, consideration should be given to the provision of speed enforcement cameras that are automatically coordinated with the variation of the speed limit.

FIGURE 5.7 : EXIT CLOSURE



5.8 Variable Message Sign (VMS)

5.8.1 Any measure imposed on the SRN for controlling traffic will not be effective unless it is respected and observed by the motorists. To enforce these measures, assistance from the Traffic Police may be required. This may not be a satisfactory solution because a considerable amount of police resources are required.

5.8.2 To improve the self enforceability of the traffic control measures, it is suggested that the motorists should also be advised of the cause for imposing these control measures. For example, if the motorist is made aware of the occurrence of an incident ahead, he will be more willing to obey the lane signals knowing that the affected lane is blocked ahead.

5.8.3 The VMS is a device by which the traffic control system can communicate with the motorists. The main objective is to provide warning of the hazards ahead for the motorists. Examples of warning messages include congestion, accident, roadworks, diversion, strong wind, slippery road, fog, etc. To make fullest use of the display, they can be used to display other information of interest to the motorist under normal traffic conditions, e.g. current time and temperature, etc. Journey time may also be displayed when and where appropriate. In case of exceptionally congested traffic, journey time may alleviate driver frustration. However, it is not necessary to provide journey time information on site under normal circumstances except at certain locations where traffic is usually heavy and alternative routes are readily available for the driver to make a choice on the road.

5.8.4 Careful consideration should be given to the design of the message for display to the motorists. These messages should be very concise and easily understood by the motorists. They should be displayed in both English and Chinese. Serious consideration should be given to the use of symbolic messages whenever practicable. Messages with characters flowing across the display should not be used as it would increase the perception time and would cause unnecessarily long distraction to the approaching motorists. The full and stationary type of messages should be used.

5.8.5 A VMS shall be accompanied by a pair of wig-wag yellow lamps, one on each end of the display. These amber lamps should be activated whenever a message requires the alertness of the motorist. Figure 5.9 shows an arrangement for the variable message display.

5.8.6 The VMS is informatory in nature to the motorists. As a guideline for reference, ***VMSs are recommended at 1.5 km upstream of every approach to each SRN-SRN interchange*** and their locations on the mainline should be carefully considered in conjunction with functionality, site conditions and cost. Sufficient visibility distance is critical for locating large VMS on the SRN. Generally, an ***'exposure time'of some 8 seconds*** should be provided for motorists to digest the messages display on the gantry type VMS on the SRN, or a ***visibility distance of about 250m for a road section with 100 kph speed limit***. Smaller ***roadside VMSs*** at more important entrances to the SRN should also be considered.

5.8.7 The messages displayed on the VMSs shall be fully configurable by the operator.

FIGURE 5.8: SPEED LIMIT CONTROL

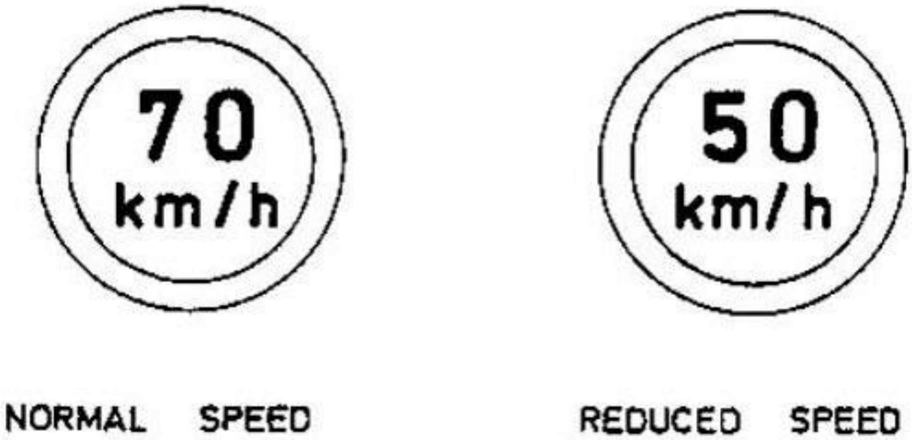


FIGURE 5.9: VARIABLE MESSAGE DISPLAY

5.9 Construction Types of VMS

5.9.1 This section describes the different type of technologies available for the construction of the variable signs including the variable speed limit sign, the variable message display, the secret sign for entrance/exit closure, etc.

5.9.2 The variable signs can broadly be divided into electro-mechanical, matrix and fibre-optics types.

5.9.3 For the electro-mechanical signs, various designs are available. These include rotatable laminae, rotary prisms, roller blind, rollers and sliding panels etc. The rotary prism type is most commonly used because of its simpler construction and reliability. The main disadvantage of this type of VMS are the limited number of displays (sign faces) and difficulties in replacing the messages with new ones. However, the manufacturers are now considering features to facilitate easy sign face modifications. These signs, because of the painted sign faces, are most suitable for variable directional signs with pre-planned diversion routes.

5.9.4 The LED matrix type VMSs are suitable for displaying general informatory messages. Coloured, full matrix type VMSs are becoming popular and should be considered for their versatility.

5.9.5 The fibre-optics sign is similar to the matrix sign in appearance. It is less flexible and can only display pre-determined messages. The number of messages which can be displayed is also limited and is dependent on the relative complexity of the messages. In the last decade, when the LED type signs were being developed, the fibre-optics signs were widely used for lane signals and secret signs. With the advent of cheap and advanced LED VMS, which are extremely energy efficient and relatively maintenance free, the use of fibre-optics signs should diminish.

5.10 Speed Enforcement Camera (SEC)

5.10.1 SECs are used to take photographs of the licence numbers of vehicles travelling above speed limits in order to facilitate Police in the enforcement of traffic regulations. As Police are the user of the SECs, planning and design of an SEC system must be worked out with Police.

5.10.2 There is no rigid criteria for determining spacing of SECs. In principle they should be spaced close enough to deter those drivers who would try to beat the system by speeding between camera sites and slowing down at each site. Whether these cameras should be mounted on gantries, pole or underneath bridges should be considered based on effectiveness, operational efficiency and ease of maintenance. One SEC per traffic flow direction is recommended for every 5 km on the SRN. Additional camera housings at about 1 km spacing can be provided for accommodating cameras in rotation can be considered if a greater deterrent effect is warranted. Site constraints such as availability of power supply and sight distance usually impose restrictions on the SEC location.

5.10.3 At the time of updating this Volume of the TPDM, TD and Police are implementing, as a new initiative, digital SECs mounted on poles. As technology advances, other options should also be considered. One of the main factors that should be considered is reliability and integrity of the evidence produced by the system to be submitted to court in the prosecution process.

6.1 References

1 **Maunsell Consultants Asia**, *Comprehensive Traffic Surveillance and Control Study, Main Report,* **1980**.

2 **TCSD, Transport Department**, *A Preliminary Study on the Introduction of an Information and Advance Warning System in Hong Kong,* **1989**.

3 **Hyder Consulting**, *Consultancy Study on the Provision, Management and Operation of Traffic Control and Surveillance Facilities for the Strategic Road Network*, **1999**.

6.2 Introduction

6.2.1 Traffic surveillance facilities described in Chapters 3 and 4 are provided to monitor traffic on the SRN so that any incident occurring on the road network can be identified quickly. Upon detection of an incident, the appropriate traffic control measures described in Chapter 5 can be applied. These control measures are aimed at informing motorists of the incident, directing them away from the incident site, ensuring safety at the incident site and assisting emergency vehicles to arrive at the incident site as quickly as possible. The last activity which remains to be carried out is the removal of the incident and the restoration of the affected section of the SRN to normal operation. It is the purpose of this chapter to discuss the incident recovery process.

6.2.2 An incident will cause blockage of the SRN either at the lane level or at the carriageway level. This could lead to congestion and delay to the traffic upstream of the incident site and also in the adjacent road network because of the decisions made by the motorist to divert and to avoid the affected section of the SRN. To minimise the delay and congestion caused by the incident, adequate provision should be made to allow clearance of the incident site in the shortest possible time after the incident has occurred.

6.2.3 Traffic accidents and vehicle breakdowns contribute to the majority of the common incidents on the SRN. The recovery process discussed in this chapter is mainly focussed on these types of incident. There are other types of incident, e.g. landslides blocking a section of the SRN, which are less common and which are required to be dealt with separately by other appropriate procedures.

6.2.4 Incident recovery service is currently provided at all tunnels in Hong Kong and the Tsing Ma Control Area (TMCA). These services are managed by the respective tunnel and TMCA operators with stringent target time limits set for the recovery process. At present, with the exception of the North Lantau Highway, no such service is available for other sections of the SRN in general, except that Police will arrange the towing of disabled vehicles if the involved parties cannot or do not do it. In the planning of the proposed TMIC, Government will consider providing incident recovery service to the entire SRN. Consideration will also need to be given to the organisational aspects of such an authority. The global trend in developed countries is to have the service provided by private operators. It is not the intention of this chapter to discuss the organisational and/or administrative aspects of incident recovery. However, guidelines will be given to enable the future SRN to be planned with adequate facilities for the provision of a satisfactory recovery service in the future.

6.3 Incident Cycle

6.3.1 Before formulating any design criteria for incident recovery, it is necessary to examine the activities involved in dealing with an incident. Although it is not possible to provide an exhaustive list of these activities, it is hoped that the following covers the common ones and that they will be given proper consideration at the design stage.

6.3.2 Occurrence The incident cycle starts with the occurrence of an incident, e.g. vehicle breakdown, vehicle out of petrol or an accident.

6.3.3 Detection The incident will be detected by the traffic surveillance system for the SRN, e.g. automatic incident detection, closed circuit television, police patrol, or reports from members of the public. The system will then alert the traffic operator at the control room of the occurrence of the incident and the appropriate traffic control measure will be activated to advise and direct the upstream traffic accordingly.

6.3.4 Mobilisation The control room operator, upon receiving an incident report, will activate the appropriate emergency and recovery services, e.g. police, fire services, ambulance and vehicle recovery, etc. to deal with the incident.

6.3.5 Travelling to site The emergency and recovery vehicles will be despatched and travel to the incident site as quickly as possible.

6.3.6 On-site activities Appropriate actions will be taken by the relevant parties (such as Police, FSD) upon arrival on site. For example, the police will carry out preliminary investigation and photographs will be taken as required; the ambulance service will attend to casualties if any and preparatory work for towing of the vehicle will be done by the recovery team.

6.3.7 Towing on the SRN When on-site activities are completed, the vehicle involved in the incident will be towed away to the nearest exit on the SRN. At the same time, any debris arising from the incident will be cleared.

6.3.8 Restoring traffic As soon as the affected vehicle is moved away from the SRN area and the incident site is cleared, the temporary traffic control measures imposed earlier can be terminated and traffic flow will be returned to normal.

6.3.9 Depending on the policy, the vehicle involved in the incident can either be towed back to the recovery centre or left in a suitable place at the exit of the SRN for further detailed investigation by the police if necessary.

6.4 Design Considerations

6.4.1 It is difficult to formulate design standards for the provision of the incident recovery facility. It should be recognised that incidents are after all not regular occurrences and that the recovery facility is quite costly to provide as it involves the acquisition of land and expensive recovery equipment. A proper balance will need to be sought between tolerable traffic disruption/congestion and cost.

6.4.2 The design standard is further complicated by the fact that incidents usually have different degrees of seriousness and their effects on traffic are not the same. Different types of incidents will have different characteristics and the time required for their clearance is not the same. For example, it may only take a relatively short time to remove a broken down vehicle, but for an overturned lorry or bus, the time required to clear the incident site will be much longer.

6.4.3 As it is not possible to set design standards to cater for all types of incidents without incurring excessive cost, it is therefore suggested that for design purpose, a "typical incident" should be used. The typical incident should reflect the characteristics of the majority of incidents commonly occurring on the SRN. For design purposes, a typical incident is one involving one vehicle which would be capable of being towed by a light recovery vehicle. It is recognised that a longer recovery time will be required for the more serious type of incidents like an overturned vehicle, spillage of dangerous chemicals, major vehicle fire, multiple accidents and accidents involving vehicles carrying dangerous goods, etc., all of which contribute to only a small percentage of the total incidents on the SRN.

6.4.4 Traffic delays are inevitable throughout the incident cycle. The amount of delay is directly proportional to the time required to clear the incident, which in turn, depends on the capital investment on the provision of the recovery facility. It is difficult to find a suitable balance between delay and cost. Based on experience, it is suggested that a 20 minutes incident duration should be set as the target. This duration will cover the period from the occurrence of a typical incident until traffic control is restored to normal.

6.4.5 Based on this target incident duration, the duration of the various activities of the incident cycle is estimated below. These durations should be taken as a guideline for designing the traffic control and the incident recovery system.

Detection	1 minute
Mobilisation	1 minute
Travelling	6 minutes
On site work	5 minutes
Towing on SRN	5 minutes
Restore traffic	2 minutes
Total	20 minutes

6.5 Recovery Centre

6.5.1 To provide quick and adequate recovery service affect traffic incidents, the necessary equipment and recovery vehicle should be located at suitable sites in the close vicinity of the section of SRN which they serve. These sites are usually referred to as 'Breakdown Recovery Centres' which should be designed with adequate facilities to allow them to be manned 24 hours a day.

6.5.2 The spacing of the recovery centres shall be determined by making reference to the incident response time. For example, if an average travelling time of 6 minutes is allowed and assuming that the recovery vehicle can travel at ***60 km/hour*** on the SRN, then the average spacing of approximately ***10-12km*** should be used.

6.5.3 The recovery centre should, as far as possible, be located close to the entrances and exits of the SRN. This will facilitate quick access to both directions of the SRN and will minimise unnecessary travel at reduced speed on the urban road network.

6.5.4 The recovery centre should have sufficient garage space to accommodate all the recovery vehicles stationed at that centre and allowance should also be made to accommodate broken down vehicles.

6.5.5 A small office space should be provided for a supervisor and the recovery crew. The minimum office facilities including a telephone should be provided.

6.5.6 The recovery centre shall have a locker room, showers and toilet facilities. Preferably, pantry facilities should also be provided, particularly for the night duty crews.

6.5.7 The above should be considered as only broadbrush guidelines primarily related to the functional requirements of the first vehicle recovery system. It is likely that a territory wide service managed by the TMIC will be provided to all parts of SRN not managed by a specific operator upon the commissioning of the TMIC. Therefore it may be necessary for an SRN project to plan and design the recovery centre(s) only if the project is to be managed as a designated traffic control area.

6.6 Recovery Vehicle

6.6.1 There are many different types of breakdown recovery vehicles ranging from the simple ones commonly used in garages to some very sophisticated ones specialised for the rescue operation. For the purpose of this section, these recovery vehicles are classified into the light recovery and the heavy recovery types. The light recovery vehicle refers to those which are used to recover a 'typical incident' (see 6.4.3). The heavy recovery vehicles refer to those used to recover a serious incident involving large trucks, articulated vehicles or overturned vehicles. The 'Challenger' used at government tunnels is an example of this type. In detail planning of the recovery logistics, the recovery vehicles can be classified into more categories (such as light, medium and heavy with each category clearly defined) to cater for the situation pertaining to the particular section of SRN in question.

6.6.2 During the incident recovery process, it is often necessary to transport the driver and passengers of the broken down vehicle to the nearest exit of the SRN as they will not be allowed to walk on the carriageway. The design of the recovery vehicles shall make allowance to carry 3 or 4 passengers over a short distance. For accidents involving buses, consideration should be given to various options, such as the provision of coaches/crew buses at a recovery centre or getting relief buses from the bus companies through prior arrangement, for the fast transportation of passengers to safe place.

6.6.3 As motor cycles cannot be towed, allowance shall be made for the light recovery vehicle to carry a broken down motor cycle on board. Such incident may require a crew of two to lift and place the motor cycle on the recovery vehicle.

6.6.4 The recovery vehicles shall be equipped with a mobile radio facility to allow the crew to communicate with the recovery centre and to call for additional help if necessary.

6.6.5 Apart from that equipment which is necessary to recover and tow the vehicle off the carriageway, the recovery vehicle shall also carry the following:

- first aid kit
- fire extinguisher
- traffic cones and signs
- flashing lights to warn passing vehicles
- fuel transfer device

6.6.6 The recovery vehicle should be painted with a conspicuous colour with retro-reflective marking. It should be equipped with flashing lights to allow visibility from the front when moving and also good warning from the rear. It should comply with all requirements stipulated in the Road Traffic (Expressway) Regulations.

6.6.7 The number of recovery vehicles to be provided at a recovery centre will depend on the incident rate of the area served by that centre and the required response time. For the number of light recovery vehicles, it is suggested that an estimation should be made as follows. The duration of the incident cycle plus a reasonable time to allow the recovery vehicle to travel back to the centre and be re-equipped with the necessary supplies should be used to estimate the maximum incident rate which it can handle. The number of light recovery vehicles can then be calculated by comparing this rate with the average incident rate expected in the area. As an example, if the incident cycle takes 20 minutes to complete and a further 15 minutes is allowed for re-equipping the vehicle, then one vehicle is able to handle 1.71 incidents per hour. If the average incident rate is 2.5 per hour in the area, a total of two light recovery vehicles will be required.

6.6.8 In deciding on the total number of light recovery vehicles, adequate consideration should be given to allow for the maintenance requirement of these vehicles if the overall performance of the system is not to be sacrificed.

6.6.9 The heavy recovery vehicle is much more expensive than the light recovery one. Care should be taken not to over-provide this type of equipment at the recovery centre particularly when the great majority of incidents do not require the service of such a vehicle. It is also recognised that in the case of a serious incident, the incident response time will become less critical compared to that for the entire incident cycle as it will take a much longer time to clear the serious incident.

6.6.10 For initial design purposes, the number of heavy recovery vehicles should be based on the criterion that the vehicle should take no longer than 20 minutes to arrive at the incident site upon receipt of the incident report. With this assumption, it may not be necessary to have one such vehicle at each recovery centre. Furthermore, consideration could also be given to make full use of such vehicles already provided at government tunnels.

6.6.11 It is likely that a territory wide service managed by the TMIC will be provided to all parts of SRN not managed by a specific operator upon the commissioning of the TMIC. Therefore it may be necessary for an SRN project to plan and design the recovery vehicles only if the project is to be managed as a designated traffic control area.

6.7 Recovery Charge

6.7.1 It is not the purpose of this document to discuss the administrative aspects of the incident recovery process including the charge levied on the provision of such service to the broken down vehicle. This section attempts to draw attention to some factors which need to be carefully considered before deciding on the recovery charges.

6.7.2 The charging policy for the provision of the vehicle recovery service requires careful thought before formulation. While it is recognised that there is no reason to provide the service free of charge, the reaction of the motorists to the charging policy should also be given proper consideration.

6.7.3 There are many reasons for the need to charge for the vehicle recovery service. The obvious one is that the charge can be used to offset partly the operational and maintenance cost of the service. It will also serve as a disincentive to vehicle breakdown on the SRN and as a levy against the social disbenefit due to delay and/or congestion caused by the incident.

6.7.4 The imposition of a high charge (though not excessive) may influence the action of motorists involved in the incident. Depending on the seriousness of the breakdown, they may try to keep moving until the next exit, which would be highly undesirable. At the same time, there may be an increased tendency for them not to report the incident and to try to fix the problem by themselves on the SRN, which is dangerous and undesirable. The non-reporting of the incident will delay the recovery process and hence will induce additional delay and/or congestion to other SRN users.

6.7.5 It is suggested that the charging system should aim at encouraging motorists to report incidents, e.g. the charge levied could be less for a reported, than an unreported incident. The system should aim at discouraging incidents caused by careless vehicle maintenance, such as fuel shortage. It should also discourage drivers from abandoning their vehicles without good reason after being involved in an incident.

6.7.6 It is hoped that eventually, the charging system could contribute toward improving the standard of vehicle maintenance which would be advantageous to all users of the SRN.

6.7.7 It is likely that a territory wide charging scheme managed by the TMIC will be in place upon the commissioning of the TMIC. Therefore it may be necessary for an SRN project to consider the recovery charge only if the project is to be managed as a designated traffic control area.