1.1 References

1) 'The application of microelectronics to the control of Highway Tunnels' – T.R.R.L. Supplementary Report 833, DTp, UK, 1984.

2) 'Technical Committee Report on Road Tunnels' – Permanent International Association of Road Congress, XVIIth World Road Congress, Sydney, 1983.

3) 'Technical Committee Report No. 5 – Road Tunnels' – Permanent International Association of Road Congresses, XVIII World Road Congress, Brussels, 1987.

4) Road Tunnels (Government) Ordinance Cap. 368, Hong Kong.

5) EMSD's specification No. ESG01: General Requirement for Electronic Contracts (Issue 7) in March 2000

6) EMSD's specification No. ESG14: General Technical Specification for Monochrome and Colour Closed Circuit Television Systems (Issue 3) in June 1998

7) EMSD's specification No. ESG15: General Technical Specification for Uninterruptible Power Supply (UPS) (Issue 3) in March 1998

1.2 Purposes

1.2.1 This volume aims to outline Transport Department's functional requirements for the provision of tunnel management system which includes traffic control and surveillance, toll collection, ventilation, lighting and central monitoring and control systems. The preferred functional requirements of the various facilities are given wherever practicable and should form the basis for the provision of road tunnel management system.

1.2.2 Information contained in this Volume is intended to be used as guidelines which are subject to a continual process of refinement in the light of future development in technology, changing operational philosophies and expectation from the public. Transport Department should be fully consulted on the provision of management system in tunnels.

1.3 Contents of Volume 11

1.3.1 Chapter 1 - General

1.3.1.1 This Volume is divided into 8 chapters. Chapter 1 serves as the introduction while Chapter 2 to 7 focuses on the individual management system for road tunnels. The main systems described in Volume 11 include traffic control & surveillance, control room & operator facilities, toll collection, ventilation, lighting and central monitoring & control. Chapter 8 outlines the statutory powers and obligations confer and impose on the Administration, tunnel operators and tunnel users.

1.3.2 Chapter 2 – Traffic Control & Surveillance

1.3.2.1 This chapter describes the traffic control and surveillance facilities to be provided in road tunnels. It outlines the basic safety requirements. A brief summary of the operator man-machine interface for the traffic control & surveillance system, which is detailed in Chapter 3, is also included.

1.3.3 Chapter 3 – Control Room & Operator Facilities

1.3.3.1 This Chapter describes the facilities to be provided in both the main and minor control rooms. Also, the provision of communication facilities is described. A list of operator facilities, mainly on traffic control & surveillance aspects, is included.

1.3.4 Chapter 4 – Toll Collection

1.3.4.1 This chapter is mainly on the requirements of manual toll collection system. It gives the functional requirements of toll booth equipments, toll collection operation and monitoring, as well as central equipment and facilities.

1.3.5 Chapter 5 – Ventilation

1.3.5.1 This chapter describes the fresh air requirements in a tunnel, the different types of ventilation systems, the ventilation equipment and the different ventilation control systems. Also, it outlines the system reliability and operator man-machine interface for ventilation systems.

1.3.6 Chapter 6 – Lighting

1.3.6.1 This chapter mainly outlines the lighting design considerations, the design of luminaries, and the lighting control system. In addition, requirements on system reliability and operator man-machine interface are included.

1.3.7 Chapter 7 – Central Monitoring & Control

1.3.7.1 This chapter describes the central monitoring and control system requirements for operation in a tunnel. It describes the functional requirements of the system, its hierarchy and interface with other systems. A list of systems as depicted in chapter 7.1.1 to be monitored and controlled is included.

1.3.8 Chapter 8 – Legislation

1.3.8.1 This chapter mainly outlines the statutory powers and obligations related to the road tunnels and control area. It gives an overview of the road tunnels (Government, BOT and private tunnels) and control area legislations.

1.4 Tunnel Area

1.4.1 The Tunnel Area has to be demarcated as required by Section 6 (1) of Cap. 368 on "Road Tunnels (Government) Ordinance" This area usually extends at both ends of the tunnel tubes to the first junction with the adjoining road network, where the traffic has the last opportunity to divert. It is based on the "last entry" and "first exit" principle. The tunnel areas for non-Government tunnels are defined under individual private tunnel ordinances.

1.4.2 Tunnel management system is provided within the Tunnel Area. Normally, the Tunnel Area should be determined before detailed design of the tunnel management system proceeds.

1.5 Tunnel Management System

1.5.1 General

1.5.1.1 Reliable tunnel management system is required for the safe and efficient tunnel operation. The management system outlined in this Volume includes traffic control & surveillance, control room & operator facilities, toll collection, ventilation, lighting and central monitor and control systems. Operationally, these systems should form an integrated system although the supply of individual systems may come from different sources.

1.5.1.2 The Electrical and Mechanical Services Department (EMSD), the Architectural Services Department, Highways Department and Civil Engineering Department should be consulted regarding matters on tunnel systems and equipments, building, tunnel and immersed tubes structures respectively.

1.5.2 Objectives

1.5.2.1 Tunnel management system should be designed to meet the following general objectives:

(a) The environment within the tunnel area (e.g. air quality and lighting level) should be so maintained and controlled to ensure safe tunnel operation in both day and night.

(b) Any incident within the tunnel area, whether it be an accident, breakdown or fire etc, should be detected as soon as it occurs. Also, response to any incident should be as quickly as possible to ensure the safety of all tunnel users and minimize the chance of secondary incidents.

(c) The tunnel management system should be designed to ensure efficient tunnel operation. Vehicles using the tunnel should incur minimum delay and the tunnel should be so controlled to provide the maximum throughput.

(d) The tunnel management system should have high serviceability, be easy to maintain and incur low operating costs.

(e) The tunnel should be well protected from any possible risks such as fire and power interruptions.

(f) The tunnel management system should aim to reduce the staff cost and the number of operation staff.

(g) The tunnel management system should be able to monitor and record the performance of various equipment.

(h) Training mode capability should be provided in the tunnel management system.

1.5.3 Reliability of Power Supply System

1.5.3.1 A reliable power supply system should be provided to support all the equipment in the Tunnel Area. Normally, electricity supply is obtained from two separate feeders from separate substations of the same or different power companies. A feeder is terminated at each portal of the tunnel respectively. Each incoming feeder usually supplies approximately one half of the equipment load, but both feeders are able to take up the total load if required. If one incoming feeder fails, the remaining feeder will supply the full load of the whole tunnel. In addition to two independent supply feeders, standby diesel generator and uninterrupted power supplies (UPS) should be available.

1.5.3.2 Uninterrupted power supply system should be capable of maintaining supplies to the essential equipment for a minimum of 30 minutes so that the tunnel could be properly closed down. In general, the uninterrupted power supply system should provide supplies to the following equipment :-

(i) Emergency lighting;

(ii) Essential communication systems;

(iii) All Computer systems;

(iv) Control centre equipment / systems;

(v) Essential control and monitoring systems;

(vi) Traffic Control and Surveillance equipment;

(vii) Toll collection system.

1.5.4 Fire Services Requirements

1.5.4.1 The fire service installations and equipment required in road tunnels are stipulated in Section 4.41 of 'Code of Practice for Minimum Fire Service Installations and Equipment and Inspection, Testing and Maintenance of Installations and Equipment' published by the Fire Services Department (FSD). For the full range of fire services installations and requirements, the FSD should be consulted and their approval should be obtained.

1.5.4.2 In general, fire extinguishers and a fire alarm push button should be housed in the same niches as the emergency telephone. On removal of any extinguisher or activation of the fire alarm push button, a fire alarm will be raised in the control room, and simultaneously in the Fire Services Communication Centre of FSD through a direct line link. Separate direct links are required for tunnel and buildings at both portals for easy identification of fire incident location. Also, there should be hydrant niches housing hose reels and fire hydrants satisfying FSD requirements. The main fire alarm panel in the control room should have facilities, such as separate alarm indication for each input source for immediately identifying the source of the fire alarm.

1.5.4.3 It is essential that the standby diesel generator provided should back up all fire protection equipment and conform to 'Para. 5.8 Part V of Code of Practice for Minimum Fire Service Installations and equipment'.

1.5.4.4 The sheathing of all cables laid inside the tunnel tubes or confined space should be made of low smoke, zero halogen and fire retardant material. Cable should not be installed inside the smoke extraction duct.

2.1 References

1) 'The application of microelectronics to the control of Highway Tunnels' - T.R.R.L. Supplementary Report 833, DTp, UK, 1984.

2) EMSD's specification No. ESG01: General Requirement for Electronic Contracts (Issue 7) in March 2000

3) EMSD's specification No. ESG14: General Technical Specification for Monochrome and Colour Closed Circuit Television Systems (Issue 3) in June 1998

2.2 Introduction

2.2.1 The tunnel area should be equipped with the appropriate and necessary traffic control and surveillance facilities for the safe manoeuvre of traffic under all anticipated operating modes of the tunnel. With the help of the traffic surveillance facilities, the operator is kept aware of the true traffic status and detect incidents in the tunnel area at all times. The traffic control facilities are designed to guide the motorists through the tunnel and the tunnel area safely and efficiently. As a whole, the traffic control and surveillance system should be designed to handle all modes of operation which is related to the traffic flow in the tunnel area.

2.2.2 The tunnel has different operational modes. With the use of proper traffic control and surveillance facilities, the safe and smooth switching of operational modes can be ensured. In the case of a conventional two-tube tunnel, the normal operation condition is unidirectional traffic flow in each tube. However, the tunnel may be operated with one tube, one or two lane closed for maintenance purposes or incidence handling. Also, the tunnel may be closed completely because of fire. In addition, a special control mode is required to stop overheight vehicles from entering the tunnel.

2.2.3 Traffic control and surveillance facilities are grouped either under the category of traffic control facilities or traffic surveillance facilities in this chapter. However, it should be noted that some facilities carry both traffic control and surveillance functions and these facilities are categorized under either traffic control or surveillance facilities for the sake of convenience.

2.3 Traffic Control Facilities

2.3.1 General

2.3.1.1 The tunnel area should be equipped with the appropriate fixed and variable message signs, traffic lights and lane signals (arrows and crosses) to safely guide motorists through the tunnel and tunnel area. The tunnel may be operated in different modes i.e. combinations of lane/tube closure situations under different traffic conditions or when it is required for maintenance or incidence recovery purposes. These signs and signals are remotely controlled to suit the prevailing situations.

2.3.1.2 Due to the multitude of signs, signals and their complex combinations and co-ordinations, a number of traffic pre-defined traffic plans have to be devised and stored in a traffic control computer. The tunnel operators could make use of the appropriate traffic plan to cope with different traffic conditions. The traffic plan is activated by inputting commands and it is then executed after checking on the workstation display and/or verifying at site by the tunnel operator. This kind of traffic control system, which allow operator to smoothly operate, influence and regulate the traffic in a quick, safe and reliable manner, has proved to be a valuable tool for tunnel operations. Section 2.3.3provides more detailed information on the traffic plans.

2.3.2 Traffic Control Signals and Signs

2.3.2.1 Traffic Light Signals

(i) A minimum of 2 sets of traffic light signal units should be provided at approach roads and tunnel portals to prohibit vehicles from entering into the tunnel when circumstance arises such as the detection of overheight vehicle. It should be light emitting diode (LED) type. Signal monitoring should be provided to detect a preset percentage failure of LED pixel. Also, facilities by means of hardware and software should be provided to block the simultaneous display of conflicting green and red signals.

(ii) The traffic light signals should normally be off. When activated, it should first turn to green and followed by the 3-second leaving yellow and then red. The lane control signal downstream should also turn to the red-cross.

2.3.2.2 Lane Signals inside the tunnel

(i) Lane signals are provided throughout the whole length of the tunnel. Each signal unit may consist of 3 aspects, red-cross, downward pointing green arrow and flashing yellow. The flashing yellow is to alert the motorists to pay special attention to the road condition while the red-cross and downward pointing green arrow inform the motorist the lane situation. These signals units are usually mounted horizontally over the centre of each lane. They should be of LED type.

(ii) Back to back mounting of lane signals is required for the middle and fast lanes only for bi-directional operation. A red-cross only should be provided on the slow lane. The front and back signals should be interlocked in order not to display simultaneous green signals to motorists during bi-directional operation.

(iii) Motorists should be able to see 2 lane signals at any time when traveling along the tunnel. Unless there are special circumstances, the lane signals should be located at every 200m intervalon straight sections. For sections on horizontal or vertical curves, the spacing should be estimated with geometric calculation and meet the above requirement of the motorists seeing 2 lane signals at any time.

(iv) Reference should be made to Figure No.4 of Road Tunnels (Government) Regulations (Cap. 368 sub. leg. Unless under extreme site constraints, 200mm diameter signals should not be used to ensure that the signals could be clearly seen by the motorists.

2.3.2.3 Lane Signals at Approach Roads

Lane signals are to be provided outside the tunnel and are used for control of traffic at the approaches especially during lane closure or tunnel tube closure. These signals can be of fibre-optics or LED type with a matrix display area of 600 mm width by 700 mm height with 200 mm flashing yellows. Interlocking should be provided for the lane signals, particularly between green arrows.

2.3.2.4 Variable Traffic Signs

There are 4 main types of variable signs namely: variable traffic signs such as TS407 and TS501 for single tube operation, variable directional signs which are usually installed at the periphery of the tunnel areas to advise motorists to divert in case the tunnel becomes congested or closed, variable speed limit signs which are installed inside the tubes and secret signs for overheight vehicles. Diagram 2.3.2.4 shows the variable sign faces for easy reference.

Traffic sign for single tube operation

Display 1

Normal

Display 2

Diversion to another carriageway to right ahead

Display 3

Diversion to another carriageway to left ahead

Tunnel Directional Sign

Display 1

Normal

Display 2

Tunnel Congestion

Display 3

Tunnel Closed

Speed limit sign

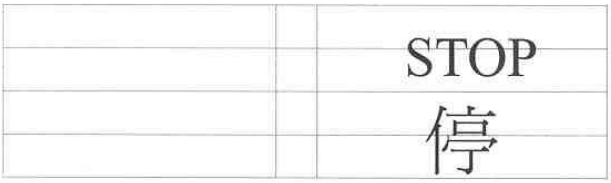
Display 1

Speed Limit 50km/hr

Display 2

Speed Limit 70km/hr

Overheight Detection – Stop Sign



Display 1

Normal

Display 2

Overheight vehicle dectected

Variable Traffic Signs

Diagram 2.3.2.4

2.3.2.5 Variable Message Sign (VMS)

Variable Message Signs shall be installed on top of the sign gantry at appropriate locations to inform motorists the latest traffic condition within the tunnel area. These signs should be able to display freely programmable English characters, Chinese characters and simple graphics in the specified matrix arrangement. A flashing yellow lamp should be provided at each end of display.

2.3.2.6 Traffic Cones

The use of pavement insert lights are not recommended due to their difficulty in restoration and replacement. Traffic cones are used at both tunnel portals for channelisation of traffic. The cones should not be less than 1m high and mounted with flashing beacons. The specifications of the traffic cones should make reference to Figure no.146 or 147 to the Schedule 1 of Road Traffic (Traffic Control) Regulations, Chapter 374 sb. leg.

2.3.2.7 Barriers

Horizontal barriers by either remote control or manual control are used to avoid traffic from driving onto the cross-over during normal operation and channelize traffic when changing the traffic operation from normal to 2-way operation in one tube and prevent vehicles from entering a closed tube. Flashing yellow warning lights should be provided on the barrier beam and the beam should be covered with alternate reflective red and white colour strips to alert the motorists. It is essential that the barriers can also be operated manually without the use of the control equipment. For safety reasons, the use of these automatic barriers has to be very carefully monitored. To ensure the safety of the approaching vehicles, the operator has to implement safety measures such as checking of site condition before activating the barrier.

2.3.3 Traffic Plans

2.3.3.1 General

(i) Traffic plans are pre-programmed plans that can change the operational status of a group of traffic control equipment. There are two main types: the planned traffic plans for scheduled events such as maintenance and the unplanned traffic plans for traffic incidents or other unplanned events such as the approach of an overheight vehicle. The unplanned traffic plans are further subdivided into incident plans and emergency plans.

2.3.3.2 Planned Traffic Plans

(i) The planned traffic plans are implemented for different modes of operation of the tunnel system, whereas each mode has its own particular traffic pattern. It should be possible, however, to amend each traffic plan manually, to suit the required conditions at a particular time.

(ii) The traffic plan normally comprises stages of successive sequence. The proposed final stage of the traffic plan should be displayed for verification by the operator. Each stage of the plan should be confirmed by the operator before proceeding to the next stage to ensure the tunnel safety. Provision should be provide to allow the operator to alter the proposed signal plan before implementation proceeds.

(iii) In general, traffic plans are devised to ensure that the following basic traffic operation procedures can be conducted safely and efficiently: -

(a) procedure for normal traffic operation,

(b) procedure for closing one tube for maintenance activities or major emergency while the other tube in one-tube-two-way operation,

(c) procedure for re-opening one tube after one-tube-two-way operation to normal operation,

(d) procedure for closing one or more lanes,

(e) procedure for re-opening one or more lanes,

(f) procedure for complete tunnel closure,

(g) procedure for opening tunnel after complete closure,

(h) procedure for dealing with overheight vehicles,

(i) manual operation (fall back mode of operation).

2.3.3.3 Unplanned Traffic Plans

(i) Incident Plans

(a) The incident plans will recommend changes to the operational status of the tunnel. Normally, the plan is divided into 2 parts. In the tunnel, the first part consists of switching commands to change the related lane signals to flashing yellow lights and the appropriate lane signals. The second part contains the switching commands to switch the modified lane signals back to the original state.

(b) The TCSS central system should contain an algorithmic plans subsystem which can, on the detection of an incident by the automatic incident detection (AID) system, recommend an appropriate incident plan. The operator can implement the recommended plan if the AID alarm is confirmed or ignore it if the alarm turns out to be false. If the operator discovers an incident by his own observation, the algorithmic plans subsystem should allow him to easily implement the appropriate incident plans.

2.3.3.4 Emergency Traffic Plan

Special traffic plans are required to handle emergency cases which require a quick response to special tunnel situations. These plans, for instance, are used to handle overheight vehicle alarm. In this case, the signals would be switched from green to the 3-second leaving yellow and then to red to stop the overheight vehicle from entering the tunnel. The lane control signals downstream should also turn to the red-cross. For these signal plans, there is no signal proposal. All signals and signs will be switched on immediately when there is an alarm. Another example is to close the tunnel immediately at the portals by activation of the tunnel closure emergency plan.

2.3.4 Individual Signal Control

2.3.4.1 The operator should be able at all times to change the operating status of any individual signal/sign or a group of similar signals/signs simultaneously. The first step of implementing individual signal switching is the proposal of the final signal status. Then, the operator can implement the signal control or stop the implementation if he considers that the proposal is not appropriate.

2.3.5 Others

2.3.5.1 Other traffic control facilities such as Public Address System and Radio Rebroadcast System with break-in facility are covered in Chapter 3.

2.4 Traffic Surveillance Facilities

2.4.1 General

2.4.1.1 The operator should be adequately informed of the prevailing traffic conditions in the tunnel area at all times. The traffic surveillance system enables the operator to detect any traffic anomalies or incidents occurring in the tunnel area.

2.4.1.2 In general, the following traffic surveillance facilities are provided:-

(i) CCTV System

(ii) Automatic incident detection system with traffic statistics functions

(iii) verheight vehicle detection

(iv) Speed enforcement system

(v) Emergency niche equipment

(vi) Emergency telephones

(vii) Weighbridge

2.4.2 CCTV

2.4.2.1 CCTV cameras should be provided to permit the monitoring of the traffic flows throughout the entire length of the tunnel and the approach roads. The spacing of the cameras should be such as to permit individual vehicles to be clearly identified and to provide continuous coverage of the tunnel area. A practical spacing between CCTV cameras inside the tunnel is about 100 m - 200 m. Cameras normally point in the normal direction of traffic flow. Therefore, the camera provides view of the back of the vehicles and is centrally mounted from the ceiling.

2.4.2.2 Each camera installed within the tunnel section should be provided with a corresponding monitor at the control center. All monitors should be fitted on the mimic map. Basically, vehicles of the permitted maximum height should be capable of being displayed in full on the appropriate monitor. Also, video recorders with time lapse facility should be available for recording the CCTV picture and for playback purpose.

2.4.2.3 All cameras should be controlled remotely in the control room. The normal control functions include pan, tilt, zoom, focus, iris operation, wiper and screen washer operation, as well as camera on-off.

2.4.3 Automatic Incident Detection

2.4.3.1 An automatic incident detection system relieves the operator from continuously watching the CCTV monitors. The incident detection system should preferably cover the entire tunnel area. It should be able to detect an incident within a maximum period of one minute with good reliability. When an incident is detected, a preprogrammed incident signal plan is proposed to assist the operator to handle the situations. The system should be able to detect incidence by lane or tube.

2.4.4 Overheight Vehicle Detection

2.4.4.1 Preferably, two set of automatic overheight vehicle detection system should be installed, one at upstream of the last diverge point before the vehicle is committed to the tunnel so that the overheight vehicle could exist at the diverge point and reduce the interruption to live traffic. The other should be installed before the tunnel portal which should have sufficient time for the tunnel operator to stop the overheight vehicle in case the motorist of the concerned vehicle fail to stop when the first detector is activated or the first detector failed to detect. In association with the height detector, height limit warning signage, "traffic signal ahead" warning signs and traffic /lane signals should be provided. When the detector detects an overheight vehicle, an alarm is activated. At the same time, at the approach road where the detector is activated the associated secret signs and traffic signals/lane signals will be switched from green to 3-second leaving yellow and then red to stop the overheight vehicle from entering the tunnel. The lane control signals downstream should also turn to the red-cross.

2.4.4.2 The system should operate reliably and features such as double beam detectors and beam plus loop method of detection should be provided to avoid false triggering of overheight vehicle detection. Meanwhile, toll booth and the PA system at the toll plaza could be used as supplementary equipment to stop the overheight vehicle.

2.4.5 Speed Enforcement System

2.4.5.1 Transport Department should be consulted regarding the installation of speed enforcement system in the tunnel area. The system should include a speed measuring device which activates a camera in taking photographs of speeding vehicles. For prosecution purposes, the photographs should incorporate details such as the time of the offence, speed detected, and, undoubtedly, the vehicle licence plate which should be clearly shown. Subject to the development of technology and court acceptability, consideration should be given to the electronic transfer of the photographs from site to the control centre for processing, thus saving the operator's time in collecting the photographs on site. For a speed enforcement system installed in the tunnel area with variable speed limit signs (VSLS), the system should be synchronized with the VSLS.

2.4.6 Emergency Niches

2.4.6.1 Emergency niches should be installed at regular intervals of 100m throughout the tunnel section. A self-illuminated sign should be provided above each niche to amplify the niche location. Each niche usually contains the following equipment: -

(i) emergency telephone,

(ii) fire extinguisher,

(iii) break-glass,

(iv) power point.

2.4.6.2 Corresponding visual alarm on the video wall and audio alarm inside the control room should be activated whenever a niche door is opened, the emergency telephone or the fire extinguisher inside the niche is picked up or the break glass alarm is activated. Meanwhile, the CCTV cameras nearby should be automatically pointing to the scene.

2.4.6.3 Also, there should be hydrant niches housing hose reels and hydrants. For the full range of fire services installations and requirements, the Fire Services Department (FSD) should be consulted and approval from FSD is required.

2.4.7 Emergency Telephones

2.4.7.1 Emergency telephones for two-way communication between the motorists and the control room are installed in niches within the tunnels.

2.4.7.2 It should be possible to dial to any selected emergency telephone from the central control room.When the operator in the central control room selected a designated emergency telephone, the indicator on the concerned niche door should flash.

2.4.7.3 Emergency telephones should be installed at regular intervals of 100m inside the niche door and should be located opposite to each other. The response time of generating an emergency telephone call from the roadside to the emergency telephone console in the control room should be less than 3 seconds.

2.4.7.4 It should have audible confirmation to the motorist that the system is operating, while waiting for reply. The system should take into consideration the exposure of the user to a noisy environment due to passing traffic, and hence the audibility must be higher than that normally provided by the public telephone system.

2.4.7.5 The operator should be able to put the caller to "hold" and attend to another incoming call and afterward re-establish conversation with the first caller. It should be possible to simultaneously "hold" any number of calls. When a called telephone is put on the "hold", the caller should be able to hear a "hold tone" in the telephone earpiece.

2.4.7.6 The emergency telephone system should be capable to conduct real time self-diagnostics test. There should be continuous automatic checking and control of the telephone channel between the central equipment and the field equipment. In case of system fault, appropriate alarms should be brought up on the emergency telephone console for attention of the operator.

2.4.8 Weighbridge

2.4.8.1 Weighbridges should be provided for the checking of overweighed vehicles at the approach roads according to the circumstance. In association with the detector to be installed, weight limit warning sign, traffic/lane signals should be provided and there should be possible diversion path for the overweighed vehicle to move away from the tunnel.

2.4.8.2 When overweight vehicle is detected, an alarm and warning sign/signal should be activated and the vehicle should be diverted to lay-by bay for further verification. The system should operate reliably and false triggering should be minimized.

2.4.8.3 The weighbridges should be capable to conduct real time self-diagnostic test. In case of system fault, appropriate alarms should be brought up on the weighbridges console for attention of the operator.

2.4.9 Cross Passage

2.4.9.1 Passenger cross passages should be provided at regular intervals of 100m throughout the tunnel. When the door is opened, there should be a corresponding indication on the video wall and audio alarm inside the control room.

2.4.9.2 These cross passages should have a clear dimension of not less than 2m wide and 2.1m high and equipped with 2 hours FRP self-closing door which can be opened on both sides.

2.4.9.3 Fixed self-illuminated exit signs for the cross passage should be provided along each cross passage doorway at a height not more than 2.5m, and the exit sign should be easily discernible in the direction of evacuation/escape.

2.4.10 Other

2.4.10.1 Other surveillance facilities such as mobile radio for tunnel vehicles are described in Chapter 3.

2.5 Basic Safety Requirements

2.5.1 System Reliability

2.5.1.1 The system must be highly reliable. The essential equipment should be configured as having redundancy particularly for in station computer, server etc., in providing high level of system reliability and serviceability. The system should employ the concepts of modular structure and graceful degradation such that a single failure of device or component will not affect the whole system operation.

2.5.1.2 There should be standby power supply connected to the traffic control and surveillance system. All system equipment in the control room and essential field equipment should be powered from uninterrupted power supply system and backed up by a standby diesel generator.

2.5.2 Equipment Monitoring

2.5.2.1 All traffic control and surveillance equipment should be continuously monitored by the central system. Equipment fault detected in aspect/status/mode change should raise an audible alarm with sound level control and logged by the system and available to the operator through the TCSS and displayed on the control console terminal and video wall.

2.5.3 Signal Interlock

2.5.3.1 For safety reasons, some traffic control equipment may only be operated in a pre-defined sequence. Unsafe operation of the traffic control equipment should be prohibited. In particular, the system should have blocking facilities to prevent conflicting signals or improper barrier positions.

2.5.3.2 The signal interlock should be achieved either by hardware or software means, or a combination of both. Such interlock should also be implemented at the local controller apart from the central equipment.

2.5.4 Fall Back Provision

2.5.4.1 Fall back mode of operation should be provided to the traffic control and surveillance system. In the normal situation, the system is operated under the computer control mode with full traffic control and surveillance facilities. When the computer control mode fails, the system should fall back to manual control mode safely by sequential logic control and it should be able to perform some basic tunnel operations such as implementation of traffic plan for lane closure inside a tunnel tube, detection of overheight vehicles and control of barriers.

2.5.4.2 In addition, field equipment should have local control facilities allowing them to be individually controlled on site. Once the field equipment is under local control mode, the computer control can no longer exert control over the equipment but can maintain the monitoring function over the field equipment.

2.6 Operator Man-Machine Interface

2.6.1 The main operator man-machine interface for the traffic control and surveillance system is located in the central control room and the minor control room. The facilities of this operation man-machine interface have been described in detail in Section 5 of Chapter 3 and are only briefly mentioned here.

2.6.2 In brief, the operator man-machine interface should have the following facilities :-

(i) operator console containing all monitoring and control units for the traffic control and surveillance system,

(ii) colour graphic video display units (VDUs) as the main operator man-machine interface to the central control system,

(iii) video wall together with the associated CCTV monitors to allow an overall view of the tunnel situation,

(iv) event logging and report generation facilities, and

(v) remote manual control facilities.

2.6.3 Access control to the central control system should be provided. There should be different user access levels for different users, such as the control room staff, operator, supervisor, software manager, hardware engineer etc. Each user level should have different access privileges to the system. It should be possible to redefine the access privileges for each level of users.

2.7 Expandability

2.7.1 The system should be capable of easy expansion by upgrading the hardware or modifying the software. Any addition of field equipment should not require substantial reconfiguration of the software.

3.1 References

1) 'The application of microelectronics to the control of Highway Tunnels' - T.R.R.L. Supplementary Report 833, DTp, UK, 1984.

2) Draft Departmental Brief on "Tunnel Management System" - T.D., H.K., 1985.

3) Road Tunnels (Government) Ordinance Cap. 368, Hong Kong.

4) Road Tunnels (Government) Regulations, Hong Kong.

3.2 Central Control Room

3.2.1 General

3.2.1.1 The central control room is the place where all monitoring and control of the tunnel operation and related equipment take place, such as traffic control and surveillance, power supply and tunnel lighting, ventilation system, toll collection system, and other services requiring centralized control. The central control room layout should be so designed to permit two operators to man the traffic control and surveillance system under normal conditions. The operator is stationed at a purpose-designed control console into which the majority of control equipment is installed. Most monitoring signals are displayed on the mimic map. If toll collection is involved, the control room should be designed for 3-man operation. A separate toll console should be provided for the toll collection system for the second operator to work on the toll collection system. It is essential that all control and surveillance facilities should be centralized and available to the operator at hand. During emergency, additional staff (e.g. Police and FSD) are expected to join the operation inside the central control room.

3.2.1.2 The entire control centre area should be equipped with computer-room type double flooring and clear room height should not be less than 3 m.

3.2.2 Video Display Panel

3.2.2.1 The video display panel is the most important aid to the operator. It indicates the current traffic configuration applying to the tunnel area. Also, it reports on the prevailing traffic operating conditions and state of the traffic control and surveillance system at any time. Normally, the video display panel is situated vertically in front of the operator console.

3.2.2.2 The video display panel should form a traffic display panel on which there is a schematic mimic representation of the tunnel area. The position of the video display representation of the tunnel route should be in the central part of the displayed panel, surrounded by CCTV monitors. Indicator/icons in various colours and shapes representing the traffic control and surveillance equipment are overlaid at relative locations of the mimic map and reveal the operating state of the equipment. These status readouts for the system should in general include the following :-

(i) Video walls

(ii) traffic signals,

(iii) lane signals,

(iv) variable traffic signs,

(v) barriers,

(vi) CCTV cameras,

(vii) emergency telephones,

(viii) overheight vehicle detectors,

(ix) road saturation levels in different colours

(x) automatic incident detectors,

(xi) niche doors,

(xii) cross passage doors,

(xiii) traffic flow direction and condition in form of histogram.

3.2.3 Operator Console

3.2.3.1 For the operator console, there is an operator control desk containing all monitoring and control units, required for the tunnel operation and the traffic surveillance and control, which have to be at hand immediately available to the operator. It shall form a control desk from which the regularly required interactions to the system can be initiated by the operator. The following basic facilities should be provided on the operator console :-

(i) control units for the traffic control and surveillance system, lighting and ventilation control systems. In the case of computer-based system, it would probably include the colour graphic terminals;

(ii) panel for computer state indication and magnetic card reader for system 'log-in' in case of computer-based system;

(iii) CCTV control panel; 2 nos. CCTV desk monitors; VCR remote control panel; VCR microphone and loudspeaker;

(iv) Radio control panel; microphone for radio; loudspeaker for radio;

(v) Public address control panel; public address loudspeaker;

(vi) Emergency telephone control panel; emergency telephone handset;

(vii) Public telephone handset; Telephone with direct line to FSD; telephone with direct line to HKPF;

(viii) Internal intercom control unit;

(ix) Any emergency control switches;

(x) A clear writing area for the operator.

3.2.4 Wall Panel Display

3.2.4.1 Normally, remote manual control panel(usually with indicators) for ventilation, lighting, power supply, environmental monitoring and alarm annunciation panels for fire, ventilation etc. are wall mounted in the central control room. They should be visible to the operator when he is stationed to the operator console and easily accessible.

3.2.5 Ventilation

3.2.5.1 General

The ventilation of the control room and the control room equipment should be controlled by air conditioning system. The air conditioning system should be designed with such capability that the environmental conditions can be maintained 24 hours a day, 7 days a week, including period of routine and fault maintenance.

3.2.5.2 Environmental conditions

The air conditioning system should ensure that the following environmental conditions are maintained all the time.

(i) Temperature

The nominal ambient air temperature should not higher than the normal room temperature. There should be provisions to allow the operator to adjust the temperature. The temperature difference between any points should not exceed 3 degree C.

(ii) Relative humidity

The relative humidity should remain at 50% plus or minus 5%, without condensation.

(iii) Fresh air

Sufficient intake of fresh air should be provided to maintain oxygen content. Temperature and humidity sensing devices should be provided in the computer and equipment area for continuous monitoring of temperature and humidity. Also, the viewing windows to be provided on the internal partition walls separating the computer area should be suitably sealed and double glazed. Double doors should be provided at the entrances to the control room to serve both as an air lock and fire proof device. The air inside computer room should be slightly pressurized to prevent influx of dust when the doors are open. It is preferable to have automatic fire fighting equipment installed inside the equipment room, which can be activated or deactivated by a key switch at the entrance.

3.2.6 Viewing Window

3.2.6.1 Viewing windows should be provided to the central control room so that the operator can actually observe the traffic condition at the toll plaza and the portal area. All windows on the external walls should be suitably coated to reduce solar heat gain. Also, curtains blinds should be provided as appropriate. Preferably the curtains blinds are electrically operated. Heavy rain should not affect the visibility of the operator from observing the actual traffic conditions.

3.2.7 Lighting

3.2.7.1 Sufficient light illumination should be provided in the control room such that the operator could see the display of indication panels and mimic map clearly and carry out written work. The control desk, toll console and the minor control room should be provided with essential lighting. Additional special local lighting should be provided as appropriate. This will take the form of adjustable spot light mounted on tracks so that they can be adjusted. Separate dimmers should be provided for the normal and additional lighting provided in the control room. Attention should be given to the lighting design to rectify the excess lighting and the glaring effect from the viewing window.

3.2.8 Security of Access

3.2.8.1 All doors should be self-closing and under emergency, doors should be able to push open from inside. Preferably the external doors should be protected with a security system such as a card operated locking system.

3.2.9 Videowall System and CCTV Monitors

3.2.9.1 An assembly of videowall and CCTV monitors shall be installed in the Control Room. The video shall provide an overview of the status of various field equipment and the conditions of the road network within the Tunnel Area and its vicinity., whereas lines of CCTV monitors should be installed at eye level to provide separate displays for live traffic. The monitors should provide100% coverage of the tunnel area, and approach roads if deemed necessarily. Each CCTV camera inside the tunnel tube should be supported by a dedicated CCTV monitor

3.2.9.2 The size of the monitors depends on the viewing distance in the control room. Monitors with 400mm screen are satisfactory at a viewing distance of 3 meters and 600mm monitors up to a distance of 6 meters. Standard facilities including but not limited to the adjustment of brightness, contrast and focus of the picture display should be provided to each monitor. Local and remote facilities at the CCTV control panel for switching on or off of the monitor are required. Consideration should be taken during the design for reducing glare caused by the reflection of ambient light on surface of monitor screens to enhance the comfort of viewing and clearness of video images.

3.3 Minor Control Room

3.3.1 While there is a central control room in the Administration Building located at one portal of the tunnel, another minor control room is situated on the other portal area to facilitate the handling of incidents occurred near the other side of portal area . This minor control room should have an operator console with the following facilities :-

(i) A TCSS workstation showing the operating status of the equipment in the portal area under its jurisdiction.

(ii) Control of traffic light signals should be done when delegated by the central control room. Critical manual fallback controls should be equipped with in the minor control room for emergency applications.

(iii) telephone and intercom facilities connected to the central control room.

(iv) CCTV monitors and appropriate controls for cameras covering the pertinentportal tunnel area;

(v) public address facilities.

3.3.2 The central control room has operation priority on the use of public address and CCTV camera control facilities. Operator could use the CCTV camera and public address control facilities in the minor control room if control is transferred from the central control room or there is no conflict against the current operation. Also, first aid facilities and some storage space for traffic signs and other traffic aids should be provided there. Besides, sufficient light illumination and viewing windows should be provided.

3.4 Communication Provisions

3.4.1 Public Address System

3.4.1.1 Good public address (PA) system should be provided at the tunnel portals and the toll plaza. This public address system should facilitate transmission of short messages and instructions to the public under critical traffic situations such as congestion, accidents and fire. Also, an audio tape recorder with remote playback control facility should be provided. It should be able to record up to five standard message up to 5 minutes duration each on a tape or similar device in several languages. It should be possible to play back any selected message automatically on demand.

3.4.1.2 There should be gooseneck microphone and monitoring loudspeakers with volume controls installed on the operator console. The frequency range of the system should not be less than 300 to 8000 Hz.

3.4.1.3 The public address system should be operated from the control console. The following controls should be provided :

(i) selection of the loudspeaker section(s)

(ii) announcement gong control

(iii) ‘speak’ control and ‘volume’ control

(iv) control for the tape recorded message

(v) system ‘on’, ‘off’ and lamp test control.

3.4.1.4 An announcement signal, such as a two-tone gone is usually mounted when the 'speak' button is depressed. This announcement signal should last no longer than 5 sec. Both the operators in the control room and the minor control room could use the PA system. But only one operator should be able to use the PA system at any time. The operator at the central control room has priority in using the PA system.

3.4.2 Radio Communication System

3.4.2.1 A radio communication system should be provided to operate throughout the tunnel. This system should have the following facilities :-

(i) Separate radio facilities should be provided for Fire Services, Police and tunnel operation.

(ii) leaky cables and associated equipment installed inside the tubes for transmission of the various type of radio signals.

(iii) Foot patrols should be provided with 'Radio Telephone' set to be carried at the waist with the mouth-piece carried at the shoulder (similar to that of Police) to facilitate safe and secure conveyance in addition to allowing both hands to direct traffic or positioning of traffic cones.

3.4.2.2 The radio equipment should be weather proof so that they can be operated under the environmental conditions in Hong Kong. Approval from Office of the Telecommunication Authority should be sought for frequency allocation, specification on transmission power and type approval of the transceivers used.

3.4.2.3 As mobile phone operators would install their mobile phone equipment inside the tunnel tube to ensure their level of service, provisions should be made to accommodate the mobile phone operators equipment.

3.4.3 Radio Rebroadcast

3.4.3.1 Radio re-broadcasting with break-in facilities should be provided. Office of the Telecommunications Authority should be consulted on the wide range of radio frequency and power transmission. The system should be capable of re-broadcasting all radio station.

3.4.3.2 'Turn on Radio' signage should be erected at tunnel portal to alert the motorists to turn on the car radios for possible emergency message broadcasting.

3.4.3.3 Whenever the tunnel receives radio signals from two different broadcasting stations, Radio Data System (RDS) should be provided to ensure that the radio signals could be received clearly within the tunnel.

3.4.4 Intercom System

3.4.4.1 An intercom system with extensions should be provided to allow communication among the control rooms and other locations especially in the building and the workshop area. The intercom system normally comprises a minimum of 12 main extensions, but only the central control room and minor control room can communicate to all extensions. Collective communication to all extensions should be possible.

3.4.5 Automatic Branch Exchange (PABX) System

3.4.5.1 A PABX system should be provided to facilitate internal communication among the control staff in the buildings for operation of the tunnel in addition to the public telephone system.

3.4.6 Direct Lines

3.4.6.1 Direct telephone line connections to the Hong Kong Police Force (HKPF), FSD and Emergency Transport Co-ordination Centre (ETCC) of TD should be provided at the control rooms in consultation with the appropriate authorities.

3.5 Operator Facilities

3.5.1 Man-machine Interface

3.5.1.1 The man-machine interface to be provided should be user friendly, easy to learn and use. The main factors to be considered are :-

(i) capability of operator,

(ii) distribution of activities among various users and the possible use of access level for distribution control,

(iii) minimum training,

(iv) simple operation,

(v) human error correction,

(vi) safety check,

(vii) simple man-machine communication,

(viii) chronological event logging,

(ix) system security and level of access for each class of user.

3.5.2 Colour Graphic VDU

3.5.2.1 The TCSS workstation should have windows environment dialogue screen. Colour graphic video display units with built-in or developed graphical user interface (GUI) and input devices such as mouse should be deployed for operator workstations for the traffic control and surveillance system. It should be possible to present graphically the configuration of the various sub-system provisions for traffic control and surveillance facilities, so that the operator can interact direct with the equipment he intends to control or monitor.

3.5.2.2 Those major components of the operator workstations, such as colour graphic VDU and the associated input devices, should easily be replaced by plugging of spares/replacements without tedious hardware and/or software re-setting procedures.

3.5.3 Central Software Functions

3.5.3.1 General

The traffic control and surveillance system should communicate with the operator in two directions. His commands must be acknowledged by the system. The response time for all simultaneous operator commands must be such that all processes called shall be started within one second of the calls under all conditions. Typical scope of minimum operator functions is given in the following sections.

3.5.3.2 Status reports

(i) Overall system status

- Computer head-standby/on line status for computer-based system
- Time and date
- Major equipment or subsystem status

(ii) Traffic control (signs and signals)

- Current operational plan in operation on area
- Current plan in operation on any sub-area
- Current status of any signal
- Status of any signal controlled from the minor control room
- Status of barriers
- List for automatic plan selection
- Vehicle detectors and traffic statistics
- Status of any incident(s) detected if automatic incident detection is employed
- List of any control factors which may be used in treatment of detector information
- Traffic flow values, for all or individual detectors, for all tube and lane combination
- Detector status
- Traffic statistics

3.5.3.3 Control functions

(i) Traffic control

- Signal plan alteration for area
- Signal plan alteration for sub area(s)
- Override of individual signal status
- Override of individual barriers
- Individual signal switching
- Switching over of hot-standby computers in case of computer-based system

(ii) Detectors and traffic statistics

- Request analysis printout, etc.

3.5.3.4 Updating

(i) Overall system

- Assign operator priority levels and access level allocation
- Setting of system clock

(ii) Traffic control

- Insert new signal plans
- Update current signal plans
- Add/delete/modify parameters for automatic selection/implementation of signal plans
- Update mode of operation/type of individual signals
- Add/delete traffic control equipment

3.5.3.5 Alarm analysis and reporting facilities

Provide on demand a list and description of all outstanding alarms. Preferably the alarms are classified into groups.

3.5.3.6 Chronological event logging

Chronological logging of every control command issued by the operator, status change, alarms etc. should be provided. Each entry must be time-tagged.

4.1 References

1) 'The application of microelectronics to the control of Highway Tunnels' – T.R.R.L. Supplementary Report 833, DTp, UK, 1984.

2) Draft Departmental Brief on 'Toll Collection System' – T.D., H.K., 1985.

3) Road Tunnels (Government) Ordinance Cap. 368, Hong Kong.

4) Road Tunnels (Government) Regulations, Hong Kong.

5) EMSD's specification No. ESG01: General Requirement for Electronic Contracts (Issue 7) in March 2000.

6) EMSD's specification No. ESG15: General Technical Specification for monochrome and Colour Closed Circuit Television Systems (Issue 3) in Jun 1998.

4.2 General

4.2.1 Toll Collection System

4.2.1.1 Since it is Government's stated policy to collect tolls for the passage of vehicles through its tunnels, a toll collection system must be provided in the planning requirements of future tunnels. If a toll collection system is required in non-Government tunnels, the design guidelines described in this Chapter should be taken as reference.

4.2.1.2 This chapter describes the functional requirements of manual toll and automatic toll collection systems.

4.2.1.3 The toll collection system must be able to control and monitor all toll booths and subsequent revenue accounting together with toll collectors identification and could, if considered necessary, encompass performance monitoring. The system should therefore require dedicated computer systems. The main objective of the system is to safeguard the monies collected from tolls with a minimum of delay to traffic and to provide detailed operational statistics for revenue reconciliation. It should provide tunnel management with cash control and the necessary records to protect public revenue. The system should also provide the statistics necessary for operational requirements and resource planning.

4.2.2 Processing Capacity of Toll Collection System

4.2.2.1 The requirements for the processing capacity of toll collection system shall be carefully assessed and the capacity of the toll plaza should match that of the tunnels. The layout of the toll plaza should allow for future expansion to install more toll booths to cater for future traffic forecast.

4.2.2.2 The exact number of normal, reversible and autotoll lanes must be calculated based on design capacity of the tunnel and the predicted processing capacity for each type of toll lane. Due consideration should be given to the split of the autotoll and manual toll users which will has implication in assessing the toll lane requirements. The manual toll collection system must be capable of processing and registering vehicle throughputs of at least 1,000 vehicles per hour per lane on a continuous basis while that of autotoll system must handle at least 1,500 vehicles per hour per lane on a continuous basis. To ensure compatibility of equipment, all toll booths should be equipped at the time of opening.

4.2.2.3 For tunnels opening initially with only one tube, consideration must be given to ensure that sufficient booths are available for predicted 2 way traffic figures. Tunnels of unusual layout or design would need special and individual consideration in each application.

4.2.3 Toll Structure

4.2.3.1 The toll collection system should be able to handle collection of differential tolls determined by vehicle class, number of extra axles, time of the day, day of the week, day of the year and direction of traffic. A minimum of ten vehicle classes, six extra axles and six different charging periods per day and two directions must be provided. The system must be able to distinguish cash transactions as well as those made by tickets.

4.2.3.2 The toll collection system must be secure, highly reliable and accurate in respect of all toll transactions. It must be designed and constructed so as to provide a very high standard of overall serviceability.

4.3 Toll Booth and Toll Lane Equipment

4.3.1 Toll Booth

4.3.1.1 Each toll booth is to be suitably equipped so as to accurately monitor all toll transactions within its lane and to handle and record all information generated in this connection. The toll supervisor console in the control room should have equipment to show the toll collector's identity, controls and other indicators. There should be a toll collector console with a cashier terminal in the toll booth. A 'toll paid' sign should be mounted outside the booth to indicate to the motorist the amount he has paid. Overhead classification signs should be mounted on top of each booth facing the Control Room to show the toll supervisor the class of vehicle being registered. A loop, or similar vehicle detector connected with the printer, should be provided in each lane. Traffic lights indicating whether a booth is open or closed are required above each booth. Other equipment necessary will include the actual toll booth structure which should have a finish which can be easily cleaned. The booth should be air conditioned and able to be heated during the winter months. It will require an intercom, suitable chair, security alarm switch, adequate lighting and a fire extinguisher. Four centre booths should be reversible to cater for possible tidal flows. Toll collector console should be equipped with lockable drawers.

4.3.2 Toll Collector Terminal

4.3.2.1 The toll collector terminal in the toll booth shall have the following capabilities:-

(i) Register at least 10 classifications and 6 additional axles by separated keys.

(ii) Register of whether the toll has been paid by cash or pre-paid ticket.

(iii) Provide a cancellation key to allow cancellation of an erroneously entered vehicle classification, extra axles or- method of payment.

(iv) Control of the matrix signal, classification sign and 'toll paid' sign.

(v) Interface with the vehicle detector and axle counter to detect evasion and verify the registration.

(vi) Inhibit toll collection operations until the identity of the operator is validated.

(vii) Display the status of the equipment and the registration details.

4.3.2.2 For operation and security considerations: -

(i) the toll collector terminal must be able to operate independently. The toll collection operation will continue uninterrupted and with toll collector unaware even in the event of the failure of the central computer.

(ii) local data storage facility in the toll lane processor should able to store the data generated for more than 1 month of continuous operation at the designed toll lane processing capability and the toll data stored should be able to store transfer back to the central data processor automatically without going through the data transfer via other means.

4.3.2.3 In the event of changes in tolls levels, the system should be able to download the new toll fare table from the central computer to toll collector terminal. Should the central computer be out of service or the communications between the central computer and a toll collector terminal fail, a portable computer must be available to locally download toll fare table to and retrieve toll data from the toll collector terminal. The retrieved toll data should be uploaded to the central computer later to generate toll reports.

4.3.3 Construction

(i) Specifications of the typical matrix signals fitted above the toll lanes are shown in Diagrams 4.3.1.3 and 4.3.1.2 of Chapter 4, Volume 3.

(ii) Lane width between toll booths shall be not less than 3.00 m while that of the autotoll lane must not be less than 3.65 m vice versa.

(iii) The outermost lanes should be able to allow the passage of exceptionally wide vehicles. The minimum width of these extra-wide lanes should be not less than 6.2m.

(iv) Toll booths should be constructed with an easy to clean exterior finish. Interior finish should include a purpose designed desk with two lockable drawers and forced ventilation must be provided. Doors should provide a good seal against the ingress of exhaust fumes when closed. Tinted windows should be used in bronze (or similar) anodized frames. A strong comfortable chair, a power point, an air-conditioner and a heater should be included in the tollbooth specification.

(v) Tollbooths should be individually air conditioned with fresh air pipe from a source other than the toll plaza to provide a better working environment; and a positive pressure is to be maintained to prevent as far as possible the ingress of exhaust fumes.

(vi) To permit toll collection the window of the toll booth adjacent to the toll lanes should have an closable aperture measuring 630 mm x 300 mm with its lower edge being 900 mm from carriageway level. The booth window on the opposite side of the door should be easily opened to enable the toll collector to evacuate through it should any incident prohibit him to leave the toll booth from the door occur.

(vii) Safety measures should be provided on the toll island such that the toll collector in the toll booth would be protected from the traffic. A segregated access should also be provided for the toll collector to access the toll booth safely.

4.4 Toll Collection Operation and Monitoring

4.4.1 Toll Collection Operation

4.4.1.1 A toll collector coming on duty must be able to identify himself to the system by key or card. Having proved his identity to the system his identification, lane number, lane direction and time of lane opening is recorded by the central computer printed on central control room printer.

4.4.1.2 These records should be printed on the central control room printer, displayed on the toll supervisor terminal. Other information such as lane open/closed, lane direction, toll collector on duty should be updated on the toll supervisor panel in the control room. Also, a shift report for the toll collector is printed automatically at the end of his duty on the accounting printer when he removes his identifier key or card.

4.4.1.3 As a safety measure against unauthorized use, if a lane barrier is raised when the booth is not operational, an alarm should be generated. Also, an alarm should be generated when the barrier is faulty. The barrier status should be shown on the toll supervisor panel.

4.4.1.4 During the period when the lane is in operation, the toll collector registers arriving vehicles on the keyboard by operating the classification buttons, payment method and the additional axle buttons upon the collection of the appropriate toll. The registration is recorded by the lane equipment and repeated on the toll supervisor panel. The supervisory equipment continuously monitors the lane condition and presents on the toll supervisor panel current classification activity for each lane. Concurrently, the current class code number is displayed on the overhead vehicle classification sign over each active toll booth for the toll supervisor's information. Vehicle classifications on the classification sign are extinguished only by the next classification operation. Classification display on the classification sign is shown when a classification key is pressed and should not be blanked after the vehicle has left the lane. If two consecutive vehicles are of the same class then it should be blanked for a short duration.

4.4.1.5 The toll collection operation in the lanes is monitored by the toll supervisor in the central control room with the help of the toll supervisor panel and toll supervisor terminal. On the toll supervisor panel, each lane is represented by indicators depicting essential lane operation status as listed in clause 4.4.2.3

4.4.1.6 Lane opening procedure is accomplished by the toll collector successfully identifying himself to the toll collector console. He opens the barrier and then presses a control button to change the aspect of overhead matrix signal from red-cross to green arrow.

4.4.1.7 The toll collection process starts when a motorist enters the toll lane. Upon the paying of the correct toll, the toll collector acknowledges receipt by operating the appropriate classification, additional axle and payment type button activating the displays. When the motorist drives on after registration of the toll paid, the activated vehicle detector and axle counter will verify the registration details of the toll collector and complete the registration. The toll collector terminal should be used for the next registration whilst the classification and axles of the previous vehicleare being verified.

4.4.1.8 Should a toll collector make a wrong entry, he should be able to cancel the entry by pressing the cancellation button which should alert the toll supervisor at his panel, who can then immediately check whether the correct re-entry has been made. All cancellations should be recorded by the lane computer and printed by the printer.

4.4.1.9 Should a vehicle activates the loop detector before payment of toll is acknowledged by the toll collector, an audible and visible alarm will be generated at the toll supervisor desk and the toll console will be locked temporarily. The supervisor after checking whether the alarm is due to non-payment or late register can reset the lane back into service. Such event will be recorded by the system and printed as an evasion. The number of evasions recorded against daily cash summary report.

4.4.1.10 In general, each toll lane will only be equipped with either manual toll equipment or autotoll equipment. In the event that a toll lane is installed with both the autotoll and manual toll equipment, interface adapter should be installed inside the toll booth of those toll lanes. The interface adapter shall be able to accept control signals from either the manual toll equipment or autotoll equipment, and relay the corresponding signals to the classification signs and matrix signals. The operator can toggle the selector switch to the appropriate system (autotoll/manual). The interface adapter should be able to read the control signals from the corresponding system, but no data shall be exchanged between the autotoll and manual toll system. At any time, only one system shall be powered ON at each toll lane.

4.4.2 Toll Supervisor Console

4.4.2.1 Located in the central control room is the toll supervisor console which should permit one man operation. The toll supervisor console should include a toll supervisor terminal, a toll supervisor panel, two CCTV monitors, an intercom master station and a P.A. microphone.

4.4.2.2 The toll supervisor terminal must show all the detailed information of equipment status and toll collection process.

4.4.2.3 The toll supervisory panel should show the exact status of the current operation on each of toll lanes. The input should be obtained directly from the source, i.e. toll booth and not the output of the central computer. There are controls to reset alarms, override the brightness of matrix signal and classification sign, and override the login authentication. The indicators for each lane shouldinclude :-

(i) Lane Status (open/closed)

(ii) Barrier Status (open/closed)

(iii) Identification of toll collector

(iv) Vehicle classification

(v) Additional axle

(vi) Cancellation alarm (+ audible alarm)

(vii) Evasion alarm (+ audible alarm)

(viii) Discrepancy alarm (+ audible alarm)

(ix) Barrier alarm (+ audible alarm)

4.4.2.4 The time shown at the toll supervisor console should be synchronized with the clock of the central computer. The status of the central computer and workstation should be displayed at the console.

4.4.2.5 Additionally the console should be fitted with two CCTV monitors, with a minimum screen size of 300 mm, for the cameras located at the toll plaza area. There should be a control panel for the remote control of these cameras giving pan, tilt, zoom, wash and wipe facilities. Another control panel is required to control the VCR which should be equipped with audio dubbing facilities.

4.4.2.6 A printer should be provided as event and alarm logging printer in the central control room, providing an instantaneous record of all significant events such as opening/closing of a toll lane, signing on/off by a toll collector, shift changes and equipment faults. The toll supervisor would use the toll supervisor terminal for detailed monitoring of lane equipment operation and toll collection operation.

4.4.2.7 Intercom system complete with recording facilities between toll supervisor and toll collectors in the booth either individually or collectively should be provided. A PA microphone should also be provided to broadcast message to the toll plaza area.

4.4.2.8 The security beacon provided in each booth should trigger audible alarm to the toll supervisor in the central control room upon activated by the concealed foot switch in the toll booth.

4.4.3 CCTV Surveillance

4.4.3.1 A dedicated colored CCTV camera should be provided for each manual toll booth to record the lane traffic. The camera should be able to identify stationary vehicle licence plates at the toll booth and provision should be made to enable the cameras to be panned, tilted, and zoomed in. Automatic video recording of the event is also required. In addition, the coloured toll CCTV should incorporate into the TCSS CCTV system to monitor the on-going activities in toll plaza. The said CCTV surveillance requires strategically mounted cameras giving a view of the toll plaza from opposite sides.

4.4.3.2 CCTV cameras for the toll plaza should be able to clearly view all or any of the vehicle classification signs to enable the toll supervisor to monitor this activity. One set of vehicle classification signs is sufficient and these should face the Control Room.

4.4.3.3 A control panel should provide the toll supervisor with pan, tilt and zoom control of the CCTV cameras located to view the toll plaza area. Cameras should also have wash/wipe facilities. Another control panel will control the VCR which should be reliable, easy to operate and be provided with time-lapse and audio dubbing facilities. Two VCRs should be provided for video recording and playback by the toll supervisor.

4.4.3.4 Two CCTV monitors, with a minimum screen size of 300 mm, should be fitted on the toll supervisor console for the two cameras located at the toll plaza area. It should be possible to playback the VCR on these CCTV monitors.

4.4.3.5 Colour cameras should be provided to view the condition of the toll tunnel.

4.4.4 Automatic Toll Operation

4.4.4.1 Automatic toll collection in Hong Kong is provided and operated by a private company on a commercial basis. The installation of autotoll system on each toll lane in all tunnels has to be approved by Transport Department.

4.4.4.2 An autotoll system at toll plaza could speed up the toll process for commuter and to reduce the human error that might be occurred for a manual toll lane. A wireless device (tag) stored with rechargeable toll information and vehicle classification information would be installed on the vehicle for vehicle identification and payment transaction. The vehicle equipped with the tag would not need to stop for toll payment when passing through an autotoll lane. The data on the tag would be transmitted to the

lane controller to verify the data. If it is proved that the tag is a valid tag, toll would be automatically debited to the account of the tag owner. The traffic light will show the green aspect. If a vehicle without tag or with invalid tag pass through the autotoll lane, the camera installed at the autotoll lane will be activated to capture the image of the vehicle for further checking by the tunnel operator. The traffic light will show the red aspect to alert the motorists.

4.4.4.3 An Autotoll lane should be provided with the following facilities:

(i) At the entry side of autotoll lane, fibre-optics or LED type matrix signals shall be installed to indicate whether the autotoll lane is open or close. It shall be installed at the canopy to indicate the incoming vehicle and these signals shall display either Green or Red aspect accordingly. At the exit side of toll lane, one number of 1 aspect (RED) signal shall be installed at the canopy as status indicator is to warn vehicle entering in the wrong direction.

(ii) Overhead vehicle classification sign to indicate to the toll supervisor the class of vehicle being registered.

(iii) Vehicle detectors to detect vehicles as they enter and leave the lane, thus completing the registration sequence.

(iv) An Antenna installed to transmit data to/from the tag on the vehicle.

(v) A coloured camera to automatically capture the image of the vehicle licence plate when invalid tag is detected.

(vi) A pair of traffic lights indicating to motorists whether he can proceed or not and his account status.

(vii) 'Toll Paid' sign to indicate to motorist the amount he has paid.

(viii) A horizontal traffic barrier shall be installed with a "no entry" sign to prevent the passage of vehicles through a closed lane.

(ix) Two number of flood lights shall be installed for illumination of the lane.

(x) Traffic sign and road markings indicating an autotoll lane shall be installed above the lane at the canopy level and laid along the lane approaching the autotoll booth respectively. Diagram 4.4.4.1 & 2 show the existing autotoll traffic sign and road marking. The font size of the sign and road marking shall in accordance with Volume 3 of TPDM. At the moment of updating this Chapter, the autotoll traffic sign and road markings are being reviewed. Transport Department shall be consulted on the appropriateness of the traffic sign and road marking.

(xi) Two number of spot light shall be installed for illumination of the traffic sign in (x).

Diagram 4.4.4.1 Traffic Sign for Autotoll Lane

Diagram 4.4.4.2 Road Marking for Autotoll Lane

4.4.4.4 Automatic video recording of the event is also required. Dedicated video recording machine should be provided to each individual autotoll lane.

4.5 Central Computer Equipment and Facilities

4.5.1 Central Computer Equipment

4.5.1.1 The central computer system must be designed to high reliability and the entire system shall be such that there will be no loss of toll data under whatsoever failure circumstance including mains failure and processor failures. A portal processor should be available to download toll data in case the central processor breaks down. The toll collection in a toll lane should not be affected by failure of whatsoever form of the central computer equipment and such failure shall be totally transparent to the toll collector.

4.5.1.2 A printer should be provided at the toll supervisor position. This will function as a logging printer. All the activities of the toll booths such as lane opening, toll evasion could be printed out by the printer.

4.5.1.3 A toll accounting terminal with printer should be provided in the accounting room for the account staff to access toll statistics such as toll revenue and sub-shift report and other information available at his access level. All print-out of the cash details or any other information required for reconciliation purpose should only be printed on this printer.

4.5.1.4 If identity card is used for collector authentication, an encoder should be provided. It should be possible to carry out the system management function at the central computer or another engineering terminal.

4.5.1.5 Computer should be user friendly and easy for control staff to operate. It should require only simple and quick keyboard input to print out shift assignments or reports as requested. The system should have a system of access included into which is a requirement that cash details are available only to the administration staff.

4.5.1.6 The whole toll collection system must be time synchronized with the master clock of the tunnel.

4.5.2 Operation Functions and Fault Monitoring

4.5.2.1 Operation Functions

(i) Validate toll collector identity

(ii) Record transactions of toll collectors

(iii) Provide record of all transactions such as the hourly summary and sub-shift summary

(iv) Provide shift/sub-shift change information

(v) Provide operator and supervisor interventions and operation alarms

(vi) Generate reports

4.5.2.2 Equipment Fault Monitoring

The equipment of the toll collection system must be closely monitored and the fault should include, inter alia,

(i) Central Computer faults

(ii) Engineering, Toll Supervisor and Accounting Terminal faults

(iii) Toll collector terminal fault

(iv) Communication fault with toll collector terminal

(v) Classifier fault

(vi) Matrix signal fault

(vii) Barrier faults

(viii) Vehicle detector fault

(ix) Axle counter fault

(x) Toll paid sign fault

4.5.2.3 Management Function

The toll collection system must provide functions to cope with the daily operation. Such functions should include, inter alia,

(i) management of the toll fare tables according to vehicle class, number of extra axles, time of the day, day of the week, day of the year and direction of traffic

(ii) management of toll collector list

(iii) management of the shift roster tables

(iv) management of automatic printing schedule for reports

4.5.3 Statistical Functions - Reports

The system should maintain in the on-line storage of at least 2 years historical data. The historical data should be able to store on optical discs to allow data retrieval in future. Historical data should include sub-shift summary, hourly summary, event and alarm log, collector performance record and shift roster table. The system should at least include daily revenue report by collector daily traffic report, shift report and on demand reports as follow:-

4.5.3.1 Daily revenue report by collector

(i) The daily revenue report should include the following information:

(a) toll collector's identity number,

(b) lane number,

(c) sign on/off times of each sub-shift,

(d) the number of vehicle and additional axle in each class registered in each sub-shift,

(e) details of evasions, discrepancy and cancellation,

(f) the total amount of toll revenue collected in cash and tickets in each sub-shift and for the whole shift, and

(g) a grand total of the revenue received from all collectors during the 24 hour period.

(ii) This report should be automatically printed daily for a 24 hour period from 0700 of the previous day to 0700 of the following day.

4.5.3.2 Daily traffic report

(i) This report should include the total number of vehicles using the tunnel by direction, by traffic lane and by class on an hourly basis. A grand total of the daily traffic during the 24 hour period should be included. Peak period information should be available.

(ii) This report should be automatically printed daily for a 24 hour period from 00:00 of the previous day to 00:00 of the following day.

4.5.3.3 Shift Report

(i) This report should include the following information:

(a) the toll collector's identity number,

(b) the lane number,

(c) sign on/off time of each sub-shift,

(d) the number of vehicle and additional axle in each class recorded in each sub-shift,

(e) details of evasions, discrepancy and cancellation,

(f) the total amount of toll revenue collected in cash and tickets in the whole sub-shift.

(ii) This report should be automatically printed at the end of the sub-shift.

4.5.3.4 On demand reports

(i) Traffic report in the format of daily traffic report for a period of time (minimum one hour) specified by the operator.

(ii) Revenue report in the similar format as 'daily revenue by collector' but group by lane for all sub-shifts within a period of time specified by the operator.

(iii) Collector performance report in the format of the daily revenue and including performance appraisal (e.g. total number of cancellation, total number of evasion) of the collector and a period of time specified by the operator.

(iv) All the daily reports and shift reports could also be printed on demand.

4.6 Future Expansion

4.6.1 Coding the data of the system should be in common industrial format such that it can be read by any computing platform, regardless of the operating system being used to facilitate future system enhancement, replacement and/or off-site data processing.

5.1 References

1. Technical Committee Report on Road Tunnels, Permanent International Association of Road Congresses, XVIth World Road Congress, Vienna, 1979

2. Technical Committee on Road Tunnels, Permanent International Association of Road Congresses, XVIIth World Road Congress, Sydney, 1983

3. Technical Committee Report No.5 - Road Tunnels, Permanent International Association of Road Congresses, XVIII World Road Congress, Brussels, 1987, pp. 53-78

4. 'The Application of Microelectronics to the Control of Highway Tunnels' - T.R.R.L. Supplementary Report 833, DTp, UK 1984.

5. 'Code of Practice for Minimum Fire Services Installation and Equipment- Section 5.26 Smoke Extraction System', Fire Services Department.

6. Technical Committee Report on Road Tunnels, Permanent International Association of Road Congress, XIXth World Road Congress, Marrakech, 1991.

7. Technical Committee on Report Road Tunnels, Permanent International Association of Road Congress, Montreal, 1995.

8. Fire and Smoke Control in Road Tunnels, by PIARC Committee on Road Tunnels (C5), 1999

5.2 Introduction

5.2.1 A road tunnel ventilation system can be conceptually segregated into two distinct parts: the electromechanical ventilation equipment with an installed ventilation capacity to deliver the requisite volume of fresh air for the dilution of vitiated air, and the control system that ensures the effective and efficient utilization of the available ventilation capacity. This chapter focuses on the functional requirements and operator facilities of a typical control system for a tunnel ventilation system. In this context, a road tunnel is generalized to mean any section of enclosed road with a non-trivial length, typically ranging from several hundred meters to several kilometers.

5.2.2 In general, the primary objectives of a tunnel ventilation system are as follows:

(i) to continuously monitor the air quality inside the tunnel and to take such control actions as are necessary to limit the concentration of air pollutants from vehicle exhausts to acceptable levels at all times;

(ii) to control the spread of smoke in the event of a tunnel fire;

5.2.3 The design of a ventilation system usually involves the following steps, in chronological order:

(i) determination of the fresh air and smoke extraction requirements

(ii) selection of the type of ventilation system to be adopted

(iii) design of the electromechanical ventilation equipment

(iv) design of the ventilation control system

5.2.4 The details of the functional requirement are depicted in Chapter 7.

5.3 The Fresh Air And Smoke Extraction Requirements

5.3.1 The pollutants generated from vehicle exhausts essentially consist of carbon monoxide (CO), nitrogen dioxide(NO_2), and smoke. Enough fresh air must be continually introduced, artificially or naturally, to maintain the pollutant concentrations to acceptable levels at all times. The determination of the maximum levels of pollutant concentrations that can be tolerated is normally based on the latest internationally recognized PIARC standard (ref. 1 to 3, 8 to 9), and is under the jurisdiction of the Environmental Protection Department (EPD). As at the moment of updating this Volume, the criteria for air quality inside tunnel, which are based on EPD's Practice Note on Control of Air Pollution in Vehicle Tunnels 1995, are as follow:

Parameter	Maximum Concentration (average over 5 minutes)
CO	100 ppm
NO_2	1 ppm
Visibility	Below an extinction coefficient of 0.005 per meter

5.3.2 To maintain pollutant concentrations to acceptable levels, the ventilation system is required to generate enough fresh air per unit time to dilute the tunnel vitiated air under all conceivable traffic conditions. The determination of fresh air requirements is usually based on the latest empirical formulae and parameters recommended by PIARC, which take into account factors such as pollutant concentration thresholds, vehicle emission characteristics, mean traffic density/speed, gradient, altitude, etc. (ref. 1 to 3).

5.3.3 Apart from meeting the fresh air requirements, the ventilation system must also provide adequate smoke extraction in the event of a tunnel fire. A road tunnel exceed 230m in length is required to install the dynamic smoke extraction system. All smoke extraction proposals are subject to the approval of the FSD.

5.3.4 Once the fresh air and smoke extraction requirements have been identified, the next step is to determine the capacity and type of the ventilation system to meet these two criteria.

5.4 Types of Ventilation Systems

5.4.1 Depending on the manner in which fresh air is injected and vitiated air is exhausted, tunnel ventilation systems can be classified into one of the following types:

(i) natural ventilation, where fresh air is drawn in from one tunnel portal and vitiated air is expelled out of the other portal via the piston effect of moving vehicles;

(ii) longitudinal ventilation, where fresh air is drawn in from one tunnel portal and vitiated air is expelled out of the other portal via tunnel longitudinal air velocities introduced artificially;

(iii) transverse ventilation, where fresh air is injected and vitiated air is exhausted through separate perforated ducts installed along the tunnel tube;

(iv) semi-transverse ventilation, where fresh air is injected through a perforated duct installed along the tunnel tube and vitiated air is exhausted through the tunnel portals;

(v) reversible semi-transverse ventilation, where fresh air is injected through a perforated duct installed along the tunnel tube, with provision for exhaustion of vitiated air through the same duct when operated in reverse mode;

(vi) variations embodying a combination of the above types.

5.4.2 The selection of the type of ventilation system to be adopted for a particular tunnel involves the identification of the most cost-effective system to generate the necessary ventilation capacity dictated by the fresh air and smoke-extraction requirements. This process usually calls for the detailed analysis of the air flow patterns and aerodynamics under different and worst-case scenarios, interpreting the study results and submitting the same to the relevant authorities (viz. EPD, FSD, EMSD and TD) for approval.

5.5 The Electromechanical Ventilation Equipment

5.5.1 Having selected the type of ventilation system to be adopted, the next step is to undertake the design of the electromechanical ventilation equipment. The design determines the type, quantity, locations, power rating and technical characteristics of ventilation fans required to achieve the given fresh-air and smoke-extraction objectives, and is subject to approval by the EMSD and the FSD.

5.5.2 Wherever possible, the ventilation equipment should be designed to have spare capacity of not less than the capacity of one fan to allow for the loss of one fan due to fault or overhaul.

5.5.3 Power factor correction equipment should be provided as and when necessary to enable the bulk tariff rate to be charged under the Supply Rule of the respective power company.

5.5.4 The power supply to the ventilation equipment should be designed in such a way that no single power supply fault, such as the loss of a transformer or a feeder, should result in a degradation of the ventilation capacity.

5.5.5 All fans should be reset to the 'off' status under power interruptions, so that upon power resumption fans will not be automatically restarted unless commanded to do so by the computer or operator.

5.5.6 The noise generated by fans in operation should be maintained to levels acceptable to the EPD.

5.5.7 All the ventilation equipment handling fire/smoke should be suitable for continuous operation at 250^{o}C or temperature anticipated during fire whichever is higher for not less than one hour. These should include fans, motors, drivers, dampers, ductwork and duct joints.

5.5.8 The ventilation equipment employed should be proven, durable and accessible for easy maintenance, readily removal and replaceable. Adequate maintenance facilities should be provided in consultation with the EMSD.

5.6 The Ventilation Control System

5.6.1 Objectives

The primary objectives of the ventilation control system are to control and monitor all the ventilation fans and ancillary equipment in a safe, reliable, economical and efficient manner, with or without operator supervision, to ensure the optimum utilization of the available ventilation capacity at all times.

The system should be designed to support the following control modes:

(i) automatic

(ii) semi-automatic

(iii) smoke extraction

(iv) remote manual

(v) local

For all control modes, environmental sensors are indispensable as they are the only means to provide a quantitative indication of pollutant concentrations. Pollutant to be measured by the environmental sensors shall comply with the latest requirements of EPD.

5.6.2 Automatic Control Mode

Under the automatic mode, the control system should be able to effect the feedback control of the ventilation fans without operator intervention. By virtue of the level of sophistication usually involved in such control systems, computer-based control is normally required. Fan power shall be able to be adjusted automatically to extract the pollutant inside the tunnel to its acceptable limits.

Necessary features of the control algorithms are :

(i) Different threshold levels and proportionality factors should apply to uni-directional and bi-directional traffic, and facilities should be provided to allow the acquisition of pertinent traffic information such as traffic direction in each lane in each tunnel tube. Such information could readily be acquired by way of an interface to the Traffic Control & Surveillance System.

(ii) Transient Suppression - Transients or spikes of pollutants recorded by the environmental sensors should be suppressed by software/hardware filtering.

(iii) Fan Protection - All protective measures recommended by the fan manufacturer should be incorporated. These would normally include minimum on and off times, maximum number of starts within a period, staggered starting, and fan rotation to equalize run-times.

(iv) Safety Interlocks - Safety interlocks should be provided to ensure that all control operations on the electromechanical equipment are fully synchronized to prevent the development of high mechanical/ electrical stress or other hazardous conditions.

(v) Air Velocity Monitoring and Control - Tunnel longitudinal air velocities near the portal areas should be constantly monitored. Should the maximum velocity threshold value be exceeded as a result of some fans being in operation, fan power should be appropriately reduced in such a way as to maintain the air velocities to below the threshold value. However, air velocity control should be inhibited if the levels of pollution exceed its acceptable limits or there is a fire emergency, as air velocity control is subordinate to the control of pollutant concentrations or the spread of smoke. Under such circumstances, an air velocity alarm to alert the operator would suffice.

(vi) Malfunctioning Sensor Handling - Spurious control action due to malfunctioning of environmental sensors shall be avoided.

5.6.3 Semi-automatic Control Mode

Under the semi-automatic mode, individual fans or groups of fans are controlled at the discretion of the operator in the Control Room through the CMCS, with built-in protective measures and safety interlocks as stated in 5.6.2.1 (iii) and 5.6.2.1 (iv). The semi-automatic operating mode is intended to apply under abnormal conditions such as fire, very high pollutant levels, fan testing, etc. All relevant control parameters should be presented to the operator in a comprehensive and concise manner through the man-machine interface to facilitate decision-making. These include all environmental sensor readings, current states of all electromechanical equipment, traffic flow directions, alarm conditions, etc. It is desirable to keep operator input to a minimum.

5.6.4 Smoke Extraction Mode

The smoke extraction mode overrides all other control modes and is initiated by the operator upon the detection of a fire inside the tunnel. Upon activation of this mode, all fans should normally be returned to the off state pending operator commands. After that, advisory messages and menu-driven input should be provided at the man-machine interface to guide the operator through the proper procedures to turn on all the relevant fans to deal with a particular fire situation. Operator input should be kept to a minimum, and all relevant fans should be started in the shortest possible time taking account of the necessary safety measures as stated in 5.6.2.1(iii) and 5.6.2.1 (iv). Fans have to be started within a maximum time limit to prevent smoke from filling up to a dangerous level. Where fan reversal is involved, there may be a need to employ some form of fan braking mechanism to expedite the reversal process. All smoke extraction procedures are subject to approval by the FSD. The activation of the smoke extraction mode is under the jurisdiction of FSD.

5.6.5 Remote Manual Control Mode

The remote manual control mode serves as a fallback facility whereby a minimum level of control functions can still be executed in the event of the failure of computer-based control. To minimize the risk of a failure of the fallback facility itself, direct hardwired control is normally entailed. The remote manual control panel should preferably be centrally located in the Control Room, although other convenient locations may be proposed. The panel should be protected against unauthorized access by keyswitch. All fans should be controllable from the panel either in groups or individually. After a pattern of fan operation has been defined by the operator and before any control signal is sent to the field, some form of operator confirmation is required as a safeguard against inadvertent operation.

5.6.6 Local Control Mode

Under this control mode, fans are controlled by way of their respective local control panels. Located near to the fans, these local control panels are not expected to have any safety interlocks and should be provided with local/remote control selector key switches, to allow access by authorized personnel only.

5.7 Control System Reliability

5.7.1 Although the ventilation control system is manned, by virtue of the routine nature of its functions, it is expected that the system would operate autonomously and automatically for most of the time, thereby relieving the operator to attend to other non-routine tasks such as incident handling, traffic control and surveillance, etc. It is also necessary to dispense with the need for the operator to keep a close watch on faults in the system. As such, a high degree of reliability is warranted. A number of desirable features to enhance system reliability are as follows:

(i) The system should be so designed that the automatic control of fans would not be affected in any way by the failure of any single processor (central or remote) in the system, albeit with a momentary interruption.

(ii) All processor/control equipment should be powered from an uninterrupted power supply system to ensure the system's immunity to power system interruptions and disturbances.

(iii) Alternative communication paths or backup communication channels should be provided to guard against the failure of any critical communication channel dedicated for control and monitoring functions.

5.7.2 Apart from the above general requirements, specific reliability standards for tunnel smoke extraction systems exist and are promulgated by the FSD. Reference should be made to relevant documents issued by the FSD on this particular subject.

5.8 Future Refinements

5.8.1 It should be emphasized that the guidelines as set out in this chapter are subject to a continual process of refinement in the light of future developments in the technology of computerized tunnel ventilation control, as well as changing operational philosophies and expectations of the public at large. Therefore, updates to this chapter may be dispatched in future and it is essential that an up-to-date version of the chapter is used when designing for a tunnel ventilation system.

6.1 References

1. Technical Committee Report on Road Tunnels, Permanent International Association of Road Congresses, XVIth World Road Congress, Vienna, 1979

2. Technical Committee on Road Tunnels, Permanent International Association of Road Congresses, XVIIth World Road Congress, Sydney, 1983

3. Technical Committee Report No. 5 - Road Tunnels, Permanent International Association of Road Congresses, XVIII World Road Congress, Brussels, 1987

4. 'The Application of Microelectronics to the Control of Highway Tunnels' - T.R.R.L. Supplementary Report 833, DTp, UK 1984.

5. Public Lighting Design Manual, Highways Department, Hong Kong Special Administrative Region

6. International Commission on Illumination - Guide For Lighting of Road Tunnel and Underpass

7. BS5489: Part7 :1992: Code of Practice for Lighting of Tunnels and Underpasses

8. CIE (1990). CIE Publication No. 88, Guide for the Lighting of Road Tunnels and Underpass. International Commission on Illumination, Austria

6.2 Introduction

6.2.1 The primary objectives of a road tunnel lighting system are to provide a controlled reduction of lighting levels to facilitate the driver's visual adaptation to the tunnel environment as he enters the tunnel, and to provide a reliable and economical source of illumination throughout the tunnel.

6.2.2 This chapter focuses on the functional requirements and operator facilities of a typical tunnel lighting control system for a 'long' tunnel. In Hong Kong, a long tunnel ranges from several hundred meters to several kilometers in length.

6.2.3 Lighting levels are measured in terms of luminance levels (in cd/m^2), which depend on the illuminance (in lux) received and the nature of the light-reflecting surfaces concerned. Lighting Division of Highways Department has the jurisdiction over the level of illuminance

6.2.4 A driver passing through a long tunnel normally encounters several lighting zones as follows, in chronological order:

(i) Transition zone, where a phased reduction of luminance levels takes place to adapt the driver's eyes gradually to the interior lighting of the tunnel. Several lighting stages are employed. The step change in luminance level between two successive stages shall not be less than 3:1 and the lighting level shall not fall below the curve illustrated in Fig. 5.9 of CIE 88:1990.

(ii) Interior zone, where a minimum and constant level of basic lighting with uniform illuminance is maintained throughout the tunnel tube. The average luminance level for this zone should be maintained at 5-6 $cd/m^3$and 4-5 cd/m^3during daytime and nighttime respectively with stopping.

(iii) Exit zone shall have luminance level 5 times the interior zone. This zone is typically 60m.

6.2.5 The design of a tunnel lighting system usually involves the following steps, in chronological order:

(i) determination of the required luminance levels in the various tunnel lighting zones for day-time and night-time.

(ii) design of the luminaries

(iii) design of the lighting control system

More detailed descriptions of these steps are provided in the following paragraphs.

6.3 Lighting Design Considerations

6.3.1 The determination of the required luminance levels in various lighting zones should normally follow the latest recommendations in Public Lighting Design Manual published by Highways Department (HyD) of the Hong Kong Special Administrative Region, CIE (International Commission on Illumination) or PIARC (Permanent International Association of Road Congresses), subject to approval by the Lighting Division of HyD.

6.3.2 Parameters to be considered include design speeds (uni-directional and bi-directional), access zone (approach road) luminance, coefficient of diffuse reflection of various tunnel surfaces (road, wall, ceiling), and the dimensions of the tunnel proper.

6.3.3 As tunnel lighting incurs significant recurrent energy costs, energy conservation should be given due emphasis. Wherever practicable, dark-coloured non-glossy surfaces should be employed for the approach road and portal structures. Properly designed daylight screens or louvers should be placed over the immediate approach to tunnel entrance to reduce the access zone luminance. Conversely, light-coloured surfaces should as far as possible be employed for the tunnel road, wall and ceiling to improve the effectiveness of the luminaries. The effects of staining of lightly coloured surfaces within the tunnel proper through prolonged exposure to vehicle exhausts should also be taken into account.

6.4 The Luminaries

6.4.1 Generally speaking, a continuous row of fluorescent tubes is employed for the interior zone lighting, whilst strategically-located high-pressure sodium lamps are employed for the threshold, transition and exit zone reinforcing lighting. The level of illuminance of different zones inside the tunnel tubes should make reference to the Public Lighting Design Manual published by the Highways Department and the design should be approved by Lighting Division of Highways Department. From an operational point of view, the following features are considered essential:

(i) To facilitate easy cleaning of luminaries, the housing shall be corrosion resistant and dust tight (IP 65). Cable connection to the luminaries shall also be dust tight.

(ii) The overall power factor of the luminaries shall be maintained at an acceptable level specified in the Supply Rule of the respective power company.

(iii) Luminaries shall be connected to alternate electrical circuits to maintain partial lighting in an area in event of failure occurring on one circuit.

(iv) Emergency lighting should be provided throughout the entire tunnel tube. Specifically, emergency lighting shall be supplied by an uninterrupted power supply connected to an emergency generator or by a no-break generator.

(v) The construction of the luminaries should afford easy access for replacement of the electrical components housed therein.

(vi) The luminaries should be arranged in such a way to avoid flickering or glare.

(vii) High frequency electronic gear shall be adopted in fluorescent luminaries for energy saving and to facilitate dimming of fluorescent light, if required.

(viii) All internal wiring of the tunnel luminaries shall be of heat resistant materials sheathed with low smoke halogen free materials.

6.5 Power Supplies and Distribution Cables

6.5.1 The power supply shall be taken from two independent power sources. In event of failure of one power supply, the remaining power supply should be able to feed the whole lighting load by switching.
All distribution cables shall be protected from fire and mechanical damage and shall be of copper conductor, low smoke halogen free type.

6.6 The Lighting Control System

6.6.1 Objectives

The primary objective of a tunnel lighting control system is to ensure the efficient and effective utilization of the tunnel luminaries at all times for the safe passage of tunnel users, with or without operator supervision. The system should be designed to support the following control modes:

(i) automatic

(ii) remote manual

(iii) local

6.6.2 Photometers

Lighting control under automatic or remote manual control modes makes use of photometer readings at the tunnel portals. Installed near each of the tunnel portals to measure the corresponding access zone luminance, these photometers should give a reliable electrical output proportional to the external luminance under all weather conditions. Sited some distance from the tunnel entrance, they should be oriented in a direction facing the respective tunnel portals.

6.6.3 Automatic Control Mode

Under the automatic control mode, the lighting control system should operate autonomously without operator intervention. By virtue of the level of sophistication normally called for, some form of computer-based control is entailed. On the basis of the photometer reading from each of the portal, the threshold, transition and interior zone lighting is adjusted to give the required luminance levels through staged switching of the relevant luminaries. There should normally be not less than six lighting stages. Stage one is the night time stage where only basic lighting in a dimmed state is provided. Dimming may be achieved through the switching-off of fluorescent luminaries or by electronic dimming means. Stage two is the day-time basic lighting with no reinforcing lighting, whilst stage three and above involve the switching on of not only the day-time basic lighting but also banks of reinforcing luminaries in proportion to the measured external luminance on the approach road. Necessary features of the control algorithms are:

(i) Different reinforcing lighting levels should apply to uni-directional and bi-directional traffic at each entrance portal due to the different design speeds of the two modes of operation, and facilities should be available to allow the acquisition of pertinent traffic information such as traffic direction in each lane of each tunnel tube. Such information could be acquired by way of an interface to the TCSS.

(ii) Transient Suppression - Transients or spikes in the photometer readings should be suppressed by software/hardware filtering.

(iii) Malfunctioning photometer Handling - Automatic and manual facilities should be available to allow malfunctioning photometers to be detected and 'removed' from the control system, as a means to prevent spurious control actions from being issued due to bad sensor data.

(iv) Safety Interlocks - Safety interlocks should be provided to ensure that all control actions are fully synchronized to prevent the development of high electrical stress or other hazardous conditions.

6.6.4 Remote Manual Control Mode

The remote manual control mode serves as a fallback facility whereby a minimum level of control functions can still be executed in the event of the failure of automatic control. To minimize the risk of a failure of the fallback facility itself, direct hardwired control is recommended. The remote manual control panel should preferably be centrally located, although other convenient locations may be proposed. Protected against unauthorized access through keyswitch, the panel should allow, as a minimum, the control of each of the above-mentioned lighting stages and the definition of uni-directional/bi-directional traffic in each tube.

6.6.5 Local Control Mode

Under this control mode, the luminaries are controlled through their respective local control panels, which should be accessible by authorized maintenance personnel only. A remote/local control selector switch should be provided in each local control panel to ensure that luminaries under local control are not remotely controllable and vice versa.

6.7 System Reliability

Although the lighting control system is manned, by virtue of the routine nature of its functions, it is expected that the system would operate autonomously and automatically for most of the time, thereby relieving the operator to attend to other non-routine tasks such as incident handling, traffic control and surveillance, etc. It is also necessary to dispense with the need for the operator to keep a close watch on faults in the system. As such, a high degree of reliability is warranted. A number of desirable features to enhance system reliability is as follows:

(a) The system should be so designed that the automatic lighting control would not be affected in any way by the failure of any single processor (central or remote) in the system, albeit with a momentary interruption.

(b) All processor/control equipment should be powered from an uninterrupted power supply system to ensure the system's immunity to power system interruptions and disturbances.

(c) Alternative communication paths or backup communication channels should be provided to guard against the failure of any critical communication channel dedicated for control and monitoring functions.

6.8 Future Refinements

6.8.1 It should be emphasized that the guidelines as set out in this chapter are subject to a continual process of refinement in the light of future developments in the technology of computerized process control, as well as changing operational philosophies and expectations of the public at large. Therefore, updates to this chapter may be dispatched in future and it is essential that an up-to-date version of the chapter is used when designing for a tunnel lighting control system.

TPDM Volume 11 Chapter 7 – Central Monitoring and Control

7.1 Introduction

7.1.1 The tunnel central monitoring and control system (CMCS) should, but not be limited to, monitor and control the following tunnel related electrical and mechanical systems inside the tunnels, administration building and ancillary buildings: -

(i) Tunnel Ventilation System including the environmental sensors

(ii) Tunnel Lighting System

(iii) Tunnel Power Supply System including high voltage, low voltage, uninterrupted power supply and emergency generator systems

(iv) Heating, Ventilation and Air Conditioning System

(v) Plumbing and Drainage System

(vi) Security System

(vii) Fire Services System

(viii) Lifts and other E&M/Building Services installations

7.1.2 The CMCS should be a computerized system with the following minimum functions:-

(i) Control and monitoring tunnel E&M equipment;

(ii) Provide man-machine interface for tunnel operators;

(iii) Provide data storage, retrieval, analysis and reporting capability;

(iv) Manage maintenance activities and equipment inventory.

7.1.3 It is common to have ventilation control system and lighting control system embedded in CMCS nowadays. These two control systems should be implemented in the CMCS.

7.1.4 Integration of the TCSS and CMCS at the workstation level could be considered to facilitate the operator to discharge his duties efficiently.

7.2 System Architecture

7.2.1 The tunnel central monitoring and control system should be in form of a multi-tier computer configuration. The first tier is the Main Control System (MCS) comprising a pair of computers which are configured to perform the supervisory monitoring and control functions of the E&M systems. The second tier is the remote processing units which are responsible for executing all data gathering, processing and control functions. The third tier of the system is the interface with the E&M equipment being monitored and controlled. The system should be a fully integrated computer system, modular in design and expandable. New field equipment should be able to be integrated to the system while the system is on-line, without changes to the existing processing, communication equipment and field wiring.

7.2.2 Main Control System

7.2.2.1 The MCS should comprise central monitoring and control equipment as follows: -

(i) a pair of scalable computers to be the supervisory control and data acquisition (SCADA) servers of the system;

(ii) operator workstations to provide man-machine interface for the operators;

(iii) engineer workstations to provide system maintenance functions and serve as a backup to the operation workstations providing all control and monitoring functions;

(iv) event/alarm and report printers to log the event/alarm in real time and generate quality bulk reports;

(v) remote manual control panel to provide the essential control and monitoring functions for tunnel ventilation and lighting system;

(vi) mimic wall panel to show alarm and status of the essential equipment of ventilation, lighting and power supply system.

7.2.2.2 The CMCS should be connected to the master clock provided by TCSS for time synchronization.

7.2.3 Dual Remote Processing Unit and Remote Input/Output Unit

7.2.3.1 The dual remote processing unit (DRPU) should locate in buildings and serve as a data concentrator and communication processor. At one end, the DRPU should connect back to MCS through redundant communication channels and at the other end should distribute command signals and retrieve data and status feedback from the remote I/O units.

7.2.3.2 The remote I/O units should be installed near the equipment to be monitored or controlled. The remote I/O units, apart from their data gathering, should act as data controllers for the data transfer between the MCS and the field equipment.

7.2.4 Interface with Field Equipment

7.2.4.1 The remote I/O unit should interface with the tunnel ventilation system and lighting system at the motor control centre and lighting control centre respectively. These control centres should be complete with relay circuits and actuating devices to execute the local control commands issued by local controllers and remote control commands directed by DRPU and MCS.

7.2.4.2 Environmental sensors, photometers, and other E&M equipment being monitored by CMCS should be completed with sensing and transuding devices to feed the data and status signals to MCS.

7.3 System Reliability

7.3.1 The system should be so designed that the supervisory monitoring and control function in the central control room would not be affected in any way by the failure of any central computer or remote processing unit in the system, albeit with a momentary interruption.

7.3.2 All processor/control equipment should be powered from uninterrupted power supply system to ensure the system is immune to power system interruptions and disturbance. The processor should automatically restart upon the restore of power after a major power failure.

7.3.3 Alternative communication paths or backup communication channels should be provided to guard against the failure of any critical communication channel dedicated for control and monitoring functions.

7.3.4 The remote manual control panels of tunnel ventilation and lighting system should provide the essential control and monitoring functions using the hardwired approach. The details are depicted in Chapter 5and 6.

7.4 Functional Requirements

7.4.1 Real time monitoring and control

7.4.1.1 The tunnel ventilation fans, under normal operation, should be controlled automatically by the CMCS based on the real time measured levels of environmental sensors installed inside the tunnel. Failure of the sensors should be detected by CMCS to prevent erratic operation of the ventilation system.

7.4.1.2 The tunnel lighting, under normal operation, should be controlled automatically based on the real time luminance of the tunnel portals. Failure of the photometers should be detected by CMCS to prevent erratic operation of the lighting system.

7.4.1.3 The motor control centres and lighting control centres should have the highest priority of control over the ventilation and lighting system respectively. The control should be transferred from MCS by setting the selection switch to local control mode at the control centres.

7.4.1.4 For all equipment to be monitored or controlled by CMCS, the following control priorities should be furnished in the descending order: -

(i) local (from local controllers or motor control centres, lighting control centres);

(ii) control from remote manual control panel;

(iii) operator control from operation workstation; and

(iv) automatic control from central computer.

7.4.1.5 The monitoring function by CMCS should be effected through the feedback from the circuits devices, transducers, sensors installed with the field equipment.

7.4.2 Man-Machine Interface

7.4.2.1 Comprehensive graph diagrams with different levels of details should be prepared to show the real time status and analogue value of all equipment being controlled and monitored. The graphic display should be refreshed every 5 seconds or be driven by changes of the monitored equipment.

7.4.3 Historisation and Trending

7.4.3.1 The collection of process data should be configurable for each monitoring point. Historical record of both process and derived data shall be stored at intervals and format (instantaneous or average) selected by the operator.

7.4.3.2 Trending should be presented in various forms such as bar graph, line graph and table.

7.4.4 Logging

7.4.4.1 The logging system should be able to record and instantly print all operator inputs from the workstations and status feedback including field equipment and system events and alarms.

7.4.5 Reporting

7.4.5.1 Reports shall be generated on demand by the operator and on a periodic and event basis. Report outputs shall be directed to the screen of the workstation where the report is demanded or to any of the report printers on the system.

7.4.6 Alarm Initiation and Management

7.4.6.1 Visual and audible alarm initiation should include, but not limited to, the following situation: -

(i) malfunction of any piece of equipment or failure of sensors being monitored by CMCS including CMCS hardware.

(ii) system failure of the E&M systems being monitored and controlled by CMCS.

(iii) level of CO, NO_2, extinction coefficient and air velocity exceeding the warning and alarm limits.

(iv) Removal of fire extinguisher or activation for fire alarm bush button,

(v) over temperature of ventilation fans.

7.4.6.2 As a minimum, alarm should be classified as high priority alarms and low priority alarms. All alarm messages should have time stamp and should be acknowledged by operator. Those outstanding alarms should remain displayed after acknowledgement. Alarms at different status should be displayed in different colour.

7.4.7 Access Control

7.4.7.1 A password system should be implemented to control access to the MCS. Operators should login using usernames and passwords in order to gain access. The access record should be kept in the system.

7.4.8 Data Archival and Retrieval

7.4.8.1 High speed and compact sized bulk data archival/retrieval facilities should be provided for storage of control and monitoring data. Logs for all the alarms, running data, operation actions, events should be provided to ease the operation and maintenance work.

7.4.9 Maintenance Management

The CMCS should include maintenance management functions such as,

(i) Storage of equipment inventory, manufacturer and vendor information, and routine maintenance schedules

(ii) Generation of periodic maintenance schedules, emergency maintenance notification, individual work orders, maintenance history reports, and work order history.

7.5 Future Refinements

7.5.1 It should be emphasized that the guidelines as set out in this chapter are subject to a continual process of refinement in the light of future developments in the technology of SCADA, as well as changing operational philosophies and expectation from the public at large. Therefore, updates to this chapter may be dispatched in future and it is essential that an up-to-date version of the chapter is used when designing for a tunnel central monitoring and control system.

TPDM Volume 11 Chapter 8 – Legislation

8.1 References

1) Road Traffic Ordinance (Cap. 374)

2) Road Traffic (Traffic Control) Regulations (Cap. 374 sub. Leg. G).

3) Road Tunnels (Government) Ordinance (Cap. 368)

4) Road Tunnels (Government) Regulations (Cap. 368 sub. Leg. A)

5) Tsing Ma Control Area Ordinance (Cap. 498)

6) Tsing Ma Control Area (Tolls, Fees and Charges) Regulation (Cap. 498 sub. Leg. A)

7) Tsing Ma Control Area (General) Regulation (Cap. 498 sub. Leg. B)

8) Eastern Harbour Crossing Ordinance (Cap. 215)

9) Eastern Harbour Crossing Road Tunnel Regulations (Cap. 215 sub. leg. D)

10) Eastern Harbour Crossing Road Tunnel Bylaw (Cap. 215 sub. leg. E)

11) Tate's Cairn Tunnel Ordinance (Cap. 393)

12) Tate's Cairn Tunnel Regulations (Cap. 393 sub. leg. A)

13) Tate's Cairn Tunnel By-laws (Cap. 393 sub. leg. B)

14) Western Harbour Crossing Ordinance (Cap. 436)

15) Western Harbour Crossing Regulation (Cap. 436 sub. leg. C)

16) Western Harbour Crossing Bylaw (Cap. 436 sub. leg. D)

17) Tai Lam Tunnel and Yuen Long Approach Road Ordinance (Cap. 474)

18) Tai Lam Tunnel and Yuen Long Approach Road Regulation (Cap. 474 sub. leg. B)

19) Tai Lam Tunnel and Yuen Long Approach Road By-laws (Cap. 474 sub. leg. C)

20) Discovery Bay Tunnel Link Ordinance (Cap.520)

21) Discovery Bay Tunnel Link Regulation (Cap.520 sub. Leg. A)

22) Discovery Bay Tunnel Link By-laws (Cap.520 sub. Leg. B)

23) Dangerous Goods (Classification) Regulations (Cap. 295 sub. Leg. 1983 R. Ed.).

24) Interpretation and General Clauses Ordinance (Cap.1)

25) Tsing Sha Control Area Ordinance (Cap.594)

26) Tsing Sha Control Area (General) Regulation (Cap.594 sub. Leg. A)

27) Tsing Sha Control Area (Tolls, Fees and Charges) Regulation (Cap.594 sub. Leg. B)

8.2 Introduction

8.2.1 In Hong Kong, the Road Traffic Ordinance (Cap. 374) provides for the regulation of road traffic and the use of vehicles and roads (including private roads). Due to special operating environment and institutional arrangement for tunnels, specific legislation is enacted to confer and impose on the Administration, tunnel operators and users the necessary statutory powers and obligations. The purpose of this chapter is to outline such powers and obligations with a view to facilitating operational planning for tunnels. As only new Government-owned tunnels will be constructed in foreseeable future, emphasis is put on Government tunnel legislation in this chapter. Since only key issues are outlined in this chapter, reader should refer to the legislation itself. In-depth analysis, legal or literal interpretation on the legislation is required.

8.2.2 Tunnels in Hong Kong can be classified by ownership into Government, build-operate-transfer (BOT) and private ones. Government tunnels are governed by the Road Tunnels (Government) Ordinance (Cap. 368) and its subsidiary legislation. The only two exceptions are (i) Cheung Tsing Tunnel, which is situated in the Tsing Ma Control Area and is therefore governed by the Tsing Ma Control Area Ordinance (Cap. 498) and its subsidiary legislation; and (ii) Tai Wai Tunnel, Sha Tin Height's Tunnel, Eagles' Nest Tunnel and Nam Wan Tunnel in the Tsing Sha Control Area and are goverened by the Tsing Sha Control Area Ordinance (Cap. 594) and its subsidiary legislation. Government has contracted out the management of all Government tunnels to private companies through tendering. BOT tunnels are built, operated and maintained by private companies under a franchise granted in accordance with relevant Ordinance tailor-made for each tunnel and will be transferred back to Government after an agreed period of time. The only private tunnel in Hong Kong is the Discovery Bay Tunnel Link. It is built, operated and maintained by a statutory private company in accordance with the Discovery Bay Tunnel Link Ordinance (Cap. 520) and its subsidiary legislation.

8.2.3 To achieve cost efficiency, it is the policy of the Government to contract out the management of Government tunnels. Provisions are therefore provided in relevant legislation to allow the private operators to manage the Government tunnels. As regards BOT and private tunnels, legislation is enacted to empower the statutory private companies to build, operate and maintain the tunnels under the monitoring of the Government.

8.3 Government Tunnel Legislation

8.3.1 Road Tunnels (Government) Ordinance (Cap. 368)

8.3.1.1 Road Tunnels (Government) Ordinance

(i) General

The primary legislation passed by the Legislative Council for Government tunnels is the Road Tunnels (Government) Ordinance (Cap. 368). It provides for the control and regulation of vehicular and pedestrian traffic in Government road tunnels; the management of such tunnels and associated matters.

(ii) Application

The Ordinance applies to the tunnels named in the legislation and the Chief Executive may include new Government tunnels in or delete existing Government tunnels from the legislation. As at 1 January 2001, the Ordinance applies to Aberdeen Tunnel, Kai Tak Tunnel, Cross-Harbour Tunnel, Lion Rock Tunnel, Shing Mun Tunnels and Tseung Kwan O Tunnel. The Road Traffic Ordinance (Cap. 374) also applies to the Government tunnels as if the tunnels were roads within the meaning of that Ordinance. For the purposes of liability for a contravention of any legislation in Hong Kong, a Government tunnel shall be a public place.

(iii) Tunnel Boundaries

The boundaries of the Government tunnels are determined by the Commissioner for Transport ("Commissioner" and delineated on plans. The boundaries may also be amended by the Commissioner in consultation with the Director of Highways ("Director". The Road Tunnels (Government) Ordinance (Cap. 368) and its subsidiary legislation shall apply within the tunnel boundaries.

(iv) Delegation of Powers

The Commissioner may in writing delegate any other public officer to exercise the powers and perform the duties conferred or imposed on him by the Ordinance. Public officer means any person holding an office under the emolument of the Government.

(v) Management Agreement

The Government may enter into an agreement with an operator for the management of a Government tunnel. The Commissioner may in writing appoint any public officer or any person employed by an operator to be an authorized officer for the purposes of the Ordinance. An authorized officers may at any Government tunnel direct traffic, require the driver of a vehicle provide his information, search a vehicle, detain a driver and/or a vehicle, remove a vehicle and dispose it under the circumstances specified in the Ordinance. Where the driver of a vehicle is suspected of having committed an offence against the Ordinance or the Road Traffic Ordinance (Cap. 374) at any Government tunnel, any person (including both the registered owner of the vehicle and the person suspected of being the driver of the vehicle at the time of the alleged offence) shall give to an authorized officer relevant personal information of the person driving the vehicle at the time of the alleged offence.

(vi) Certificates of Image Recording, Printing Devices and Photographic Process

Certificates of image recording, printing devices and photographic process in the form specified by the Commissioner for Transport are to be admitted in any criminal or civil proceedings before any court on its production without further proof.

(vii) Vehicle etc. Causing Obstruction

If any vehicle or thing is causing an obstruction at any tunnel or is likely to render the use of the tunnel unsafe, the Commissioner or an operator may remove it at the risk and expense of the owner of such vehicle or thing. If the vehicle so removed is not claimed by the owner within the specified period, it shall become the Government property and may be sold or disposed of as the Commissioner thinks fit.

(viii) Installation of Pipes or Cables in Government Tunnels

Prior consent in writing from the Commissioner should be obtained before installation of pipes or cables in Government tunnels. The Commissioner shall consult the Director before giving any consent and the consent shall be subject to the payment of such charges and conditions as the Commissioner may impose.

(ix) Advertising in Government Tunnels

The Commissioner may use or permit the use of a tunnel for advertising purposes on such terms and conditions and for such period as he thinks fit.

(x) Remunerations under Management Agreements

With the approval of the Financial Secretary, the operator is entitled under the management agreement to retain those parts or percentages of any moneys raised or received for the purposes of the Government as remuneration.

8.3.1.2 Road Tunnels (Government) Regulations

(i) General

The Road Tunnels (Government) Ordinance, Chapter 368 confers power on the Chief Executive to make regulation in areas delineated in the Ordinance. Major provisions in the Regulations are as follows:

(ii) Prescribed Signs, Road Markings and Signal Lights

Under the Road Tunnels (Government) Regulations (Cap. 368 sub. Leg. A), the Commissioner may for the purposes of regulating and controlling traffic cause or permit to be displayed at any Government tunnels any traffic sign or road marking prescribed by the Regulations or the Road Traffic (Traffic Control) Regulation (Cap. 374 sub. Leg. G). The Commissioner where he considers that there is a temporary risk of danger to the public or of damage to a tunnel may display temporary maximum speed limit sign for vehicles using that tunnel.

(iii) Access for Vehicles and Closure of Tunnel

No person or vehicle is allowed to enter or leave any tunnel other than places specified by the Commissioner or an operator. The Commissioner may at any time close a tunnel or any part of it to all or any class or description of vehicles he may specify. With prior approval from the Commissioner or with reasonable excuse, an operator may close or partially close a tunnel to the public use.

(iv) Traffic Confined to Left-hand Lanes

A bus, medium or heavy goods vehicle, a vehicle requiring permit because of its width or length and a vehicle towing another vehicle shall be driven only in the nearside of the lanes of a tunnel except when otherwise directed or signaled by an authorized officer.

(v) General Restrictions and Prohibitions

Unless directed or signalled by an authorized officer, conforming to any traffic sign or with reasonable causes, no person is allowed to drive any vehicle in any tunnel at a speed of less than 25 kilometres per hour; stop any vehicle; alight from a vehicle; make any U turn or reverse a vehicle; refuel or repair a vehicle; or propel a vehicle by pushing it. No person is allowed to enter or remain in any part of a tunnel area on foot unless he is directed or signalled by an authorized officer to do so; authorized to do so by the Commissioner; is a public officer and needs to do so in the due execution of his duties; or does so in accordance with any legislation.

No person is allowed to drive or remain in any tunnel a bicycle, invalid carriage, motor tricycle, tricycle or rickshaw; a vehicle which is not carrying sufficient fuel in its fuel tank to enable it to be driven through; a vehicle which will or is likely to come into contact with tunnel structure or its fittings or fixtures; or a vehicle carrying any goods referred to in Categories 1, 2 and 5 of the Schedule to the Dangerous Goods (Classification) Regulations (Cap. 295 sub. Leg. 1983 R. Ed.). However, the Regulation does not prohibit the conveyance in a tunnel of fuel which is being carried in the fuel tank for the purpose only of the propulsion of the vehicle; or the conveyance in a tunnel of petroleum spirit which is being carried in a vehicle for the purposes of replenishing refueling facilities for vehicle employed on duty relating to a tunnel.

(vi) Tolls

The appropriate toll specified in the Regulations in respect of the use of a tunnel by any vehicle shall be payable by the driver of such vehicle at a toll booth provided by the Commissioner or an operator. The Commissioner may cause or permit the installation of such automatic toll collection facility at such toll booth as he may approve for the purpose of toll collection. An electronic toll pass may be issued by the Commissioner or by an operator to a person who opens an account for the payment of the toll for any tunnel.

(vii) Vehicles Requiring Permits

No person is allowed to drive in any tunnel a vehicle with a width exceeding 2.5m; with a length exceeding 12m; towing another vehicle; or drawing a trailer and their combined length exceeds 16m unless a permit is issued by the Commissioner for the passage of that vehicle. The permit fee shall be paid in accordance with the Regulations.

(viii) Exemptions

A vehicle carrying an authorized officer on duty, fire service vehicle, ambulance, police vehicle and vehicle used for defence purposes shall be exempted from specified provisions in the Regulations.

(ix) Powers of an Operator

An operator who has entered into an agreement with the Government for the management of a tunnel may exercise such powers conferred on the Commissioner under specified provisions in the Regulations and on such terms and conditions specified by the Commissioner.

8.3.2 Tsing Ma Control Area Ordinance (Cap. 498)

8.3.2.1 The Tsing Ma Control Area Ordinance (Cap. 498) provides for the control and regulation of vehicular and pedestrian traffic movements within the Tsing Ma Control Area; the delineation of that Area in respect of the management and maintenance thereof; the powers of authorized officers; the use of image recording devices; the disposal of abandoned vehicles; the closure of roads within the Area; and the imposition of financial penalties. "Tsing Ma Control Area" means the area described and delineated by the Commissioner on a plan, and includes any road, viaduct, bridge and Cheung Tsing Tunnel wholly or partially located within that Area. The Area is owned by the Government and is managed, operated and maintained by a private operator who has entered a management agreement with the Government. The Ordinance also empowers the Chief Executive in Council to make regulations for the imposition and collection of tolls payable for the use of the Lantau Link and the Secretary for Transport to make regulations for control and regulation of vehicular and pedestrian traffic movements within the Area.

8.3.2.2 The subsidiary legislation made by the Chief Executive in Council and the Secretary for Transport is Tsing Ma Control Area (Tolls, Fees and Charges) Regulation (Cap. 498 sub. Leg. A) and Tsing Ma Control Area (General) Regulation (Cap. 498 sub. Leg. B) respectively.

8.3.2.3 Unless otherwise specified, the Ordinance and its subsidiary legislation shall apply to Cheung Tsing Tunnel situated within the Area. The statutory authority of the Government and Operator in the Control Area shall be discussed in a separate chapter in the TPDM.

8.3.3 Tsing Sha Control Area Ordinance (Cap. 594)

8.3.3.1 The Tsing Sha Control Area Ordinance (Cap. 594) provides for the control and regulation of vehicular and pedestrian traffic movements within the Tsing Sha Control Area; the delineation of that Area in respect of the management and maintenance thereof; the powers of authorized officers; the use of image recording devices; the disposal of abandoned vehicles; the closure of roads within the Area; and the imposition of financial penalties. "Tsing Sha Control Area" means the area described and delineated by the Commissioner on a plan, and includes any road, viaduct, bridge and tunnels wholly or partially located within that Area. The Area is owned by the Government and is managed, operated and maintained by a private operator who has entered a management, operation and maintenance agreement with the Government. The Ordinance also empowers the Chief Executive in Council to make regulations for the imposition and collection of tolls payable for the use of the toll area and the Secretary for Transport and Housing to make regulations for control and regulation of vehicular and pedestrian traffic movements within the Area.

8.3.3.2 The subsidiary legislation made by the Chief Executive in Council and the Secretary for Transport and Housing is Tsing Sha Control Area (General) Regulation (Cap. 594 sub. Leg. A) and Tsing Sha Control Area (Tolls, Fees and Charges) Regulation (Cap. 594 sub. Leg. B) respectively.

8.4 BOT Tunnel Legislation

8.4.1 As at 1 January 2001, there are 4 BOT tunnels in Hong Kong namely, Eastern Harbour Crossing, Tate's Cairn Tunnel, Western Harbour Crossing and Tai Lam Tunnel and Yuen Long Approach Road. The construction, maintenance and operation of each BOT tunnel are governed by respective Ordinance and its subsidiary legislation as follows:

(i) Eastern Harbour Crossing Ordinance (Cap. 215);

(ii) Eastern Harbour Crossing Road Tunnel Regulations (Cap. 215 sub. leg. D);

(iii) Eastern Harbour Crossing Road Tunnel Bylaw (Cap. 215 sub. leg. E);

(iv) Tate's Cairn Tunnel Ordinance (Cap. 393);

(v) Tate's Cairn Tunnel Regulations (Cap. 393 sub. leg. A);

(vi) Tate's Cairn Tunnel By-laws (Cap. 393 sub. leg. B);

(vii) Western Harbour Crossing Ordinance (Cap. 436);

(viii) Western Harbour Crossing Regulation (Cap. 436 sub. leg. C);

(ix) Western Harbour Crossing Bylaw (Cap. 436 sub. leg. D);

(x) Tai Lam Tunnel and Yuen Long Approach Road Ordinance (Cap. 474);

(xi) Tai Lam Tunnel and Yuen Long Approach Road Regulation (Cap. 474 sub. leg. B);

(xii) Tai Lam Tunnel and Yuen Long Approach Road By-laws (Cap. 474 sub. leg. C).

8.4.2 The Ordinances provide for the granting of franchises for the construction of a road tunnel (and also rail tunnel for Eastern Harbour Crossing) and the regulation of the construction and maintenance works; for the payment of tolls to the franchise holders for the use by motor vehicles of the tunnels; for the obligation of tunnel operation and the termination and expiry of the franchises. The Ordinances also empower the Chief Executive in Council to make regulations for the safe and efficient operation of the tunnels by the tunnel companies and empower the tunnel companies to make by-laws for the regulation of vehicular traffic.

8.5 Private Tunnel Legislation

8.5.1 The only private tunnel in Hong Kong is the Discovery Bay Tunnel Link. The Discovery Bay Tunnel Link Ordinance (Cap.520) confer powers for the purpose of constructing a tunnel and a road to connect Discovery Bay in Lantau Island and Siu Ho Wan in North Lantau of that Island, to provide for the operation and the maintenance of the tunnel and the road, to permit the use of the tunnel and the road for passage of vehicular traffic, to empower the charging of tolls or fees and payment of royalties.

8.5.2 The Ordinance also confer powers on the Secretary for Transport to make regulations for the operation and maintenance of the tunnel and the road and the tunnel company to make bylaws to provide for the control, regulation, restriction and safety of traffic in the tunnel area and collection of tolls or fees in respect of the use of the Tunnel Link.