CHAPTER 8: VEHICLE-RESPONSIVE CONTROL

8.1 INTRODUCTION

1 Vehicle-responsive control at isolated junctions utilises a self-optimising strategy in which green periods are adjusted based on the calculation of a control function or performance index. The objective is to establish signal settings that optimise the performance index. This performance index could either be delay, or a combined function of delay and number stops. Traffic is counted by means of loop detectors, and traffic models are used to calculate the performance index for alternative signal settings.

2 The control strategy used in vehicle-responsive control differs from that used in vehicle-actuated control. A relatively simple strategy is used in vehicle-actuated control that would just allow the longest queue to pass through a junction on green. Actuated control, however, has a number of shortcomings that result in less than optimum control. This strategy is relatively successful when traffic flows are low, but actuated control tends to run to maximum when flows are high, resulting in less efficient or even oversaturated operations. Vehicle-responsive control would be able to optimise signal settings under both low and high traffic volumes.

3 The method of control described below is the one used in the MOVA (Microprocessor Optimised Vehicle Actuation) controller developed by the Transport Research Laboratory (TRL) in the United Kingdom. The method combines both vehicle-actuated and traffic responsive strategies and utilises the advantages of both strategies in one system. Traffic responsive control requires relative accurate measurements of traffic volumes. An accumulation of small errors in traffic counts can result in less than optimum operations. This problem can be addressed by combining the vehicle-actuated and traffic responsive control strategies.

4 MOVA is claimed to reduce vehicular delay significantly in comparison with vehicle-actuated control, and that it addresses many of the shortcomings of vehicle-actuated-control. An advantage of the system is that a microprocessor-based module has been developed which can be added to many existing traffic signal controllers. Consequently, it is not necessary to replace existing controllers.

8.2 CONTROL PRINCIPLES

1 The MOVA system uses detectors located in each lane at typically 100 m and 40 m from the stop line as shown Figure 8.1. The detector located at 100 m from the stop line is defined as the IN-detector. The detector at 40 m is defined as the X-detector.

2 Different forms of control strategies are implemented depending on traffic flow conditions. The duration of the green interval is determined by making a number of sequential decisions based on traffic flows and queue information derived from the vehicle detectors.

3 A basic decision is made to establish whether the junction is under or oversaturated. The junction is deemed to be undersaturated if queues clear the junction each cycle. When a substantial number of vehicles remain in the queue at the end of green, the junction is oversaturated. Different control strategies are used depending on whether the junction is undersaturated or oversaturated.

4 In the undersaturated condition, the duration of the green period is determined by making a number of sequential decisions based on traffic and queue information obtained from the vehicle detectors. The following control strategies are then implemented:

(a) The green period starts with the implementation of a basic **vehicle-actuated** control strategy in which provision is made for the following:

(i) An absolute minimum green followed by a further variable green that allows for vehicles stopped between the X-detector and the stop line. The variable green is estimated from a count of those vehicles that have crossed the X-detector during the preceding red period.

(ii) After the minimum green interval, the size of the "gap" between successive vehicles is measured at the X-detectors to determine if traffic is discharging at measurably less than the saturation rate. As soon as *one* lane of an approach is judged to be discharging at less than full rate, then the entire approach is judged to have reached the "end of saturation" condition. When *all* relevant approaches have individually reached end of saturation then the end of saturation is deemed to be reached.

(b) Once end of saturation has been reached and queues have departed, a **traffic responsive control** strategy is implemented in which provision is made for the following:

(i) A traffic model is used which is updated from IN- and X-detector counts. This model is used to calculate the benefit or disbenefit of extending the current green period. The benefit or disbenefit is determined as the saving in the performance index.

(ii) A check is maintained of all vehicles that will benefit and disbenefit from extending the green. The vehicles that will benefit are those that are receiving green, while vehicles that will disbenefit are those that are queuing at red signals around the junction. Traffic that is expected to arrive in the short-term future is also taken into account.

(iii) If the performance index falls to zero or below, the decision is made to change the signals. If the performance index is positive, the current green is extended.

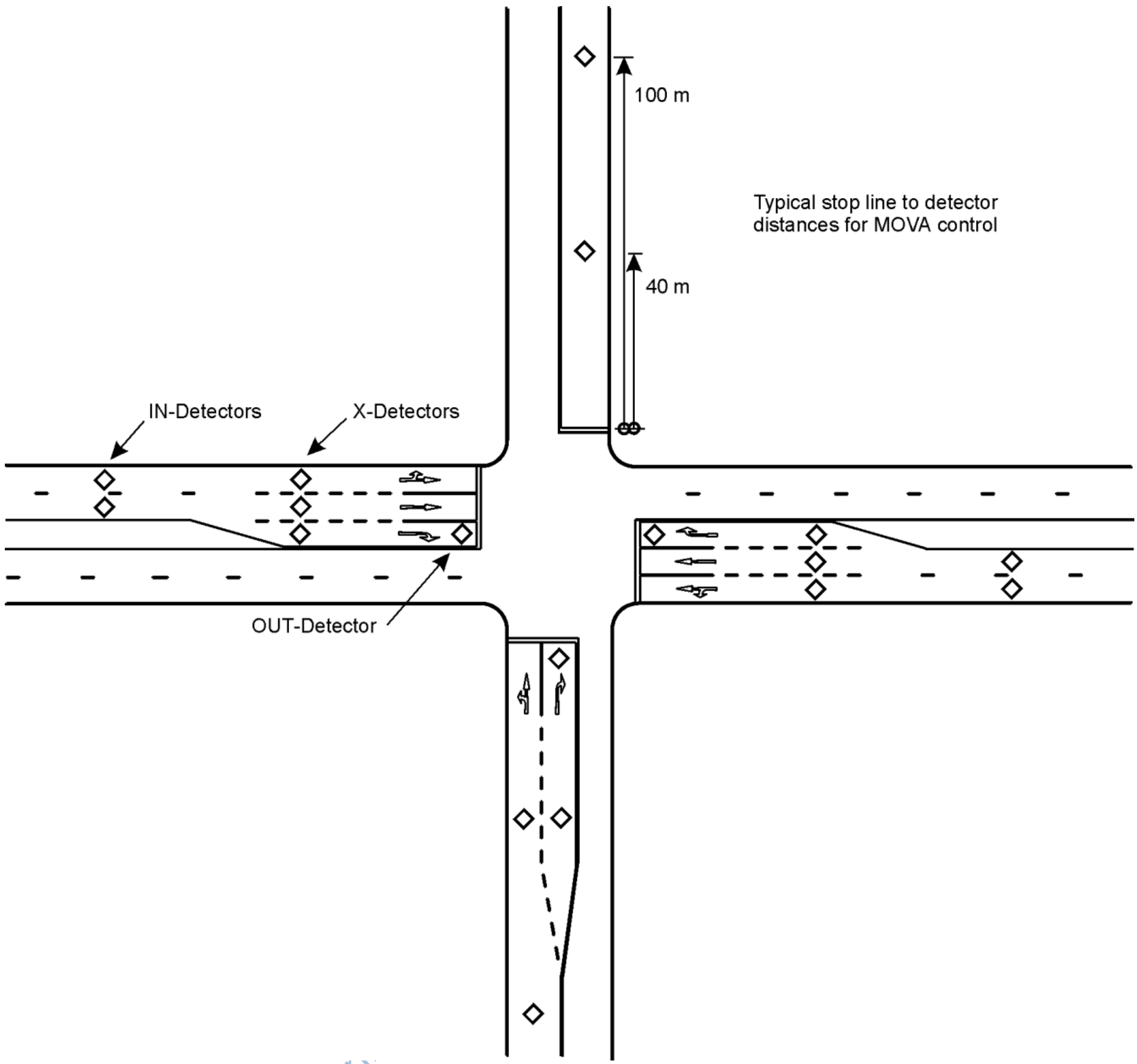

Figure 8.1: Typical layout of detectors

5 In the oversaturated condition, a control strategy is implemented which attempts to maximise capacity on congested (oversaturated) approaches. Green is maintained on oversaturated approaches provided that discharge continues at full saturation up to pre-set maximum greens. The junction will then operate on long cycles; thus minimising lost time.

6 Provision is also made for deciding whether or not an exclusive right-turn phase is required. If this facility is to be used an additional detector is required in advance of the stop line. This is referred to as the OUT-detector (see Figure 8.1). Traffic counts are used from both the OUT- and X-detectors. Should this number exceed a pre-set minimum, the exclusive right-turn phase is provided.

7 The combination of the various control strategies makes this an effective method of control. Although obviously more costly than fixed time control, the benefits to traffic and not having to update signal timings regularly, outweighs the cost substantially.

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CHAPTER 9: AREA TRAFFIC CONTROL

9.1 INTRODUCTION

1 The co-ordination of traffic signal controlled junctions is highly beneficial to the flow of traffic through a network of traffic signals or along an arterial road. The major objective in co-ordinating traffic signals is to permit continuous flow of traffic through such a network. A co-ordinated system will significantly reduce vehicular delays and stops with commensurate savings in number of accidents, fuel consumption, levels of air pollution, etc.

2 Signals at different junctions can be co-ordinated by using a common signal cycle length and a set of signal offsets that determine relative time relationships between adjacent signals. The use of a common cycle length synchronises the signals and assures that the relative timings of the signals will be repeated regularly.

3 Traffic signals can be particularly effective when co-ordinated in a network, compared to isolated control. In a network, traffic flow patterns are typically relative stable, strongly platooned and cyclic. Under such conditions, it is possible to achieve a relatively high level of efficiency. On the other hand, these same conditions can have exactly the opposite impact if signals are not properly co-ordinated. Operations can become extremely inefficient in an unco-ordinated traffic signal system.

4 Modern area traffic control systems utilise a central computer for storing and implementing traffic signal plans. This was made possible by the rapid development in computer technology and telecommunications. These systems have grown in sophistication and are commonplace in most major cities throughout the world.

5 There are numerous methods of implementing traffic signal co-ordination, ranging from the very simplistic through to real time traffic responsive control. All of these methodologies fall under the collective term of Area Traffic Control (ATC). The following systems are discussed in this chapter:

(a) Master signal control
(b) Fixed time area traffic control
(c) Adaptive area traffic control
(d) Traffic responsive area traffic control

9.2 MASTER SIGNAL CONTROL

1 A relatively simple method of co-ordinating traffic signals in a small signal network or on an arterial is by utilising a local master controller. This master controller is used to synchronise local controllers in the system.

2 The implementation of local master-slave co-ordination is shown in Figure 9.1 and requires the following equipment:

(a) A specifically designated master controller (this may be separate or it may double as a standard signal controller).
(b) Slave controllers at each road junction and signalised pedestrian crossing.
(c) A pilot cable connecting each of the slave controllers to the master.

3 The pilot cable is utilised for the transmission of information to affect timing plan changes, and to maintain synchronisation and co-ordination of the controllers.

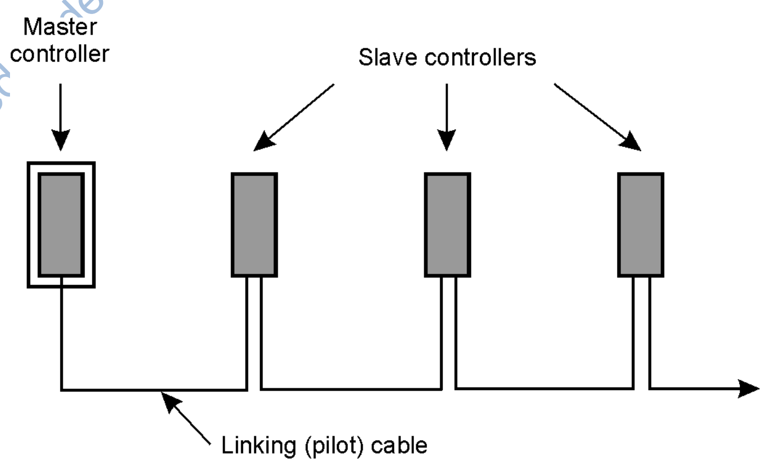

Figure 9.1: Schematic for linking co-ordinated signals

9.3 FIXED TIME AREA TRAFFIC CONTROL

1 The simplest form of area traffic signal control is by means of a fixed time system. Plan preparation is undertaken off-line and plan selection can occur by time of day or using automatic plan selection methods.

2 Automatic plan selection provides an area control system with the ability to introduce fixed time plans in response to detector inputs. A plan may be introduced on the basis of inputs such as the following:

(a) A count detector exceeding a threshold (either the absolute value or the rate of change in the traffic count).

(b) A queue detector detecting a long queue.

(c) An occupancy detector exceeding its threshold.

3 Plans can be selected by means of Boolean logical expressions or a method whereby each plan is allocated a priority based on the detector inputs. Transitional plans can be provided to allow the controller to step up or down towards the required signal plan.

4 Fixed time area control has the disadvantage that signal plans must be prepared manually. These plans must also be updated regularly to reflect changing traffic conditions, which require costly data collection and analysis. Automatic plan selection improves the flexibility of the system, but does not reduce the need for the manual and regular updating of plans.

9.4 ADAPTIVE AREA TRAFFIC CONTROL

1 Adaptive and responsive control systems have been developed with the objective of overcoming shortcomings of fixed time control systems. Such systems can react automatically to changes in traffic conditions on the road network.

2 Adaptive traffic control utilises simpler control strategies than the traffic responsive systems described in the next section. Although simpler, adaptive control can provide relative efficient traffic signal control.

3 The adaptive strategy described below is the one used in the SCATS system (Sydney Co-ordinated Adaptive Traffic System). This system was developed by the Road and Traffic Authority of New South Wales in Australia.

4 The system utilises stop line detectors for the collection of traffic flow data. A detector loop is placed in each lane approaching a junction as shown in Figure 9.2. Some lanes, however, can be left without any detectors.

5 The stop line detectors are used to estimate the *degree of saturation* for each lane approaching a junction. This degree of saturation is estimated as used green divided by total available green. Used green is taken as the number of vehicles crossing the detector multiplied by the average saturation flow headway. These degrees of saturation are used to optimise traffic signal timings as follows:

(a) Cycle lengths are established based on the degree of saturation. A target cycle length is selected, and the actual cycle length changed in steps of a few seconds in the direction of the target cycle length. A large step size is used when there is a steep change in traffic demand.

(b) Green splits are established that will result in equal degrees of saturation on critical lanes.

(c) Signal offsets are undertaken on a selection basis. A number of offsets can be provided for each link, and the system selects the offset most suitable to the level of traffic flow on the link. The offsets are calculated off-line (as for fixed time plans).

(d) Signal phases can be defined, and any phase for which no traffic demand has been registered, may be skipped.

6 The SCATS system has been extensively developed and tested, and a variety of refinements have been developed to ensure reliable operation. The system has demonstrated its value compared to fixed time control and is particularly effective when responding to unpredictable traffic patterns. Being traffic adaptive, the need for regular updating of signal settings is obviated.

9.5 TRAFFIC RESPONSIVE CONTROL

1 Traffic responsive control systems utilise a relatively complex traffic model for the on-line estimation of a performance index and establishment of optimum traffic signal settings. The system is therefore self-optimising, and can respond to changes in traffic patterns and flows.

2 The control strategy described below is the one used in the SCOOT system (Split, Cycle and Offset Optimisation Technique). This system was jointly developed by the Transportation Research Laboratory and three prominent traffic signal companies in the United Kingdom.

3 The system utilises detectors that are located some distance upstream of the stop line as shown in Figure 9.3. Traffic flows measured at these detectors are used to predict a traffic arrival profile at the downstream stop line using platoon dispersion models. An example of such a projected stop line demand profile is shown in Figure 9.4.

4 Predetermined saturation flows are used to estimate queue lengths from which delays and number of stops can be calculated. A performance index is determined as the weighted sum of delay and number of stops. This index is recalculated every few seconds from the latest traffic flow measurements, and is used to establish optimum cycle length, green splits and signal offsets.

5 The upstream detectors also have the added advantage that queues extending back to the detectors can be detected, which allow appropriate actions to be taken to avoid blocking of junctions.

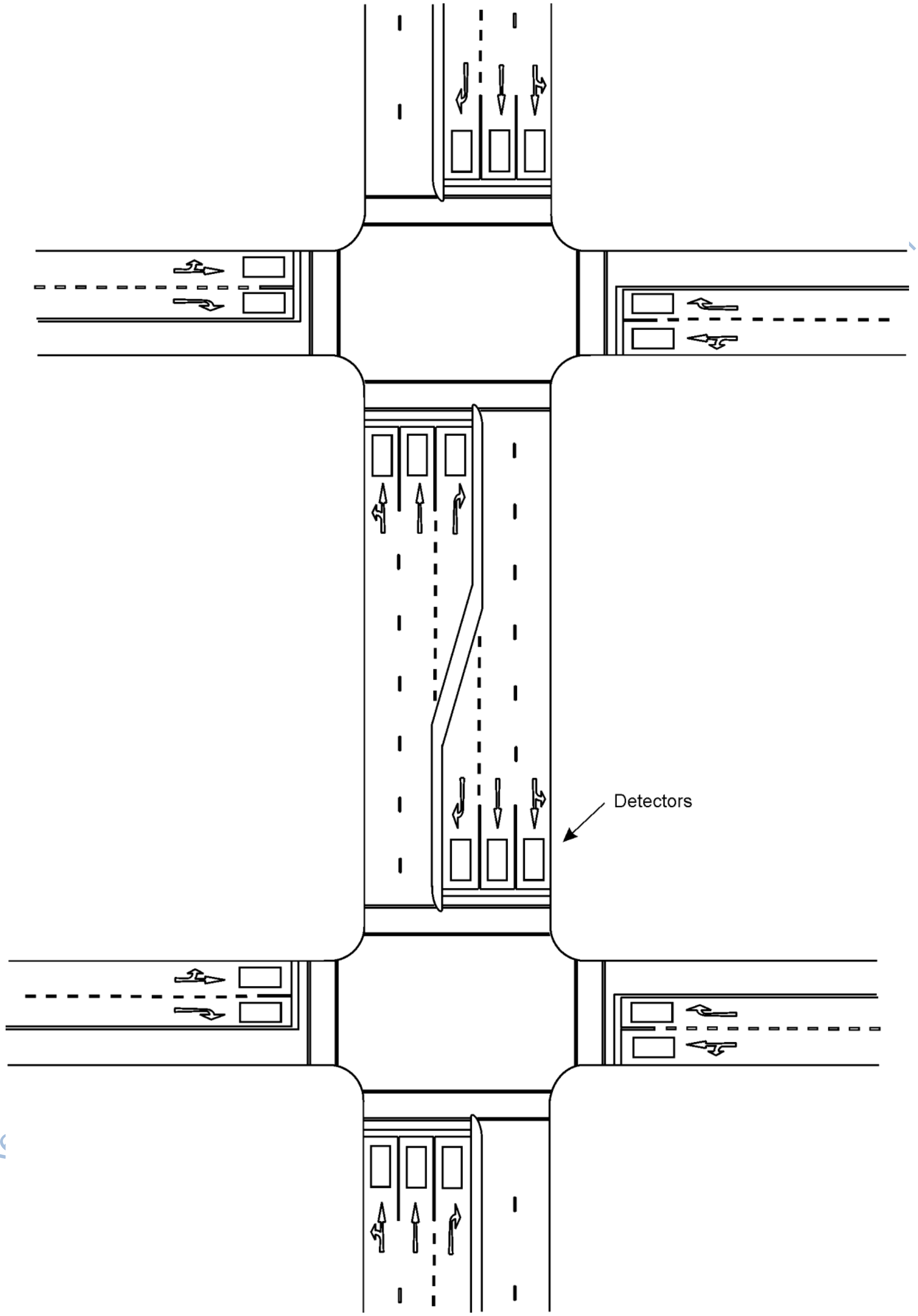

Figure 9.2: Adaptive traffic control vehicle detector layout

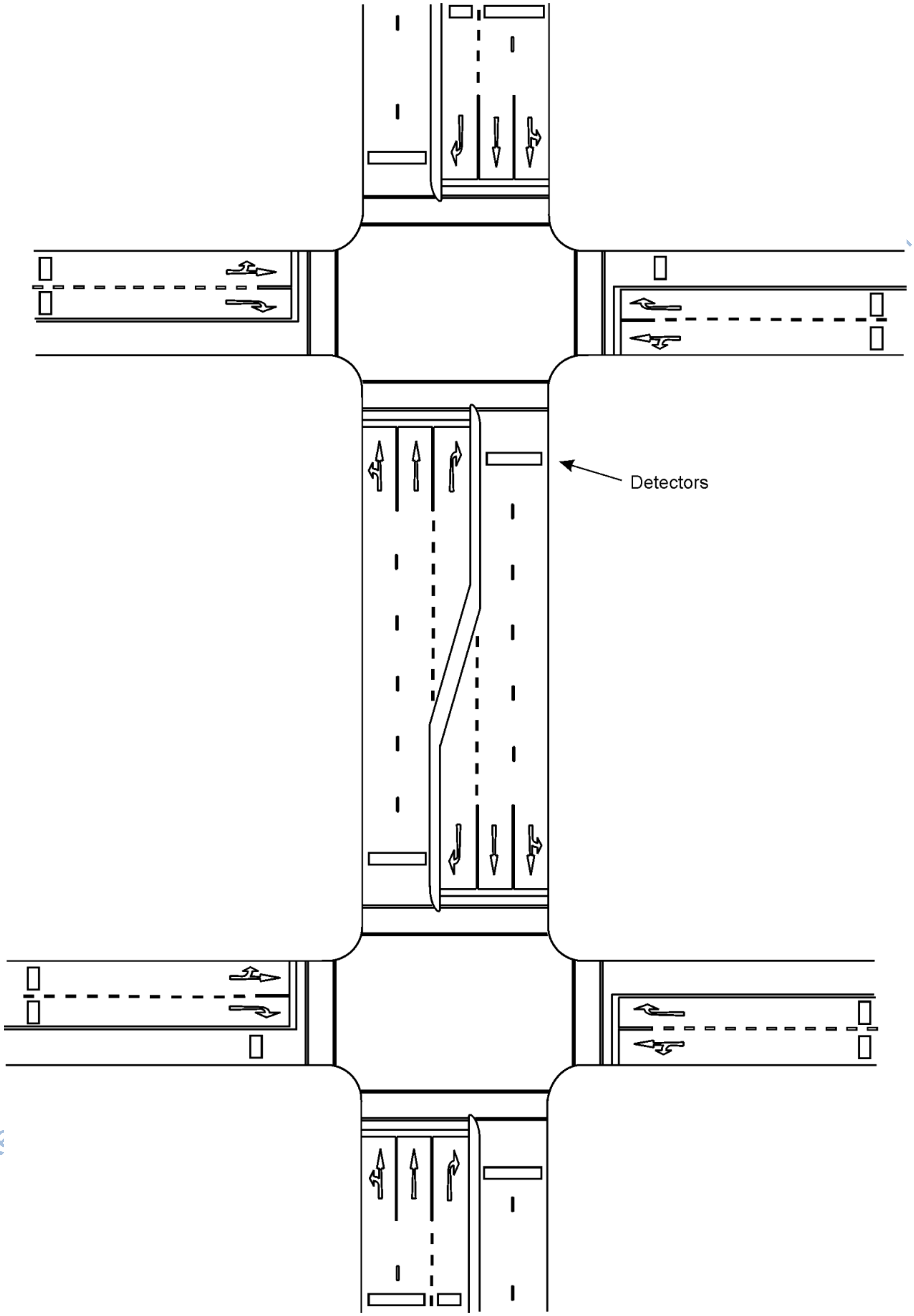

Figure 9.3: Traffic responsive control vehicle detector layout

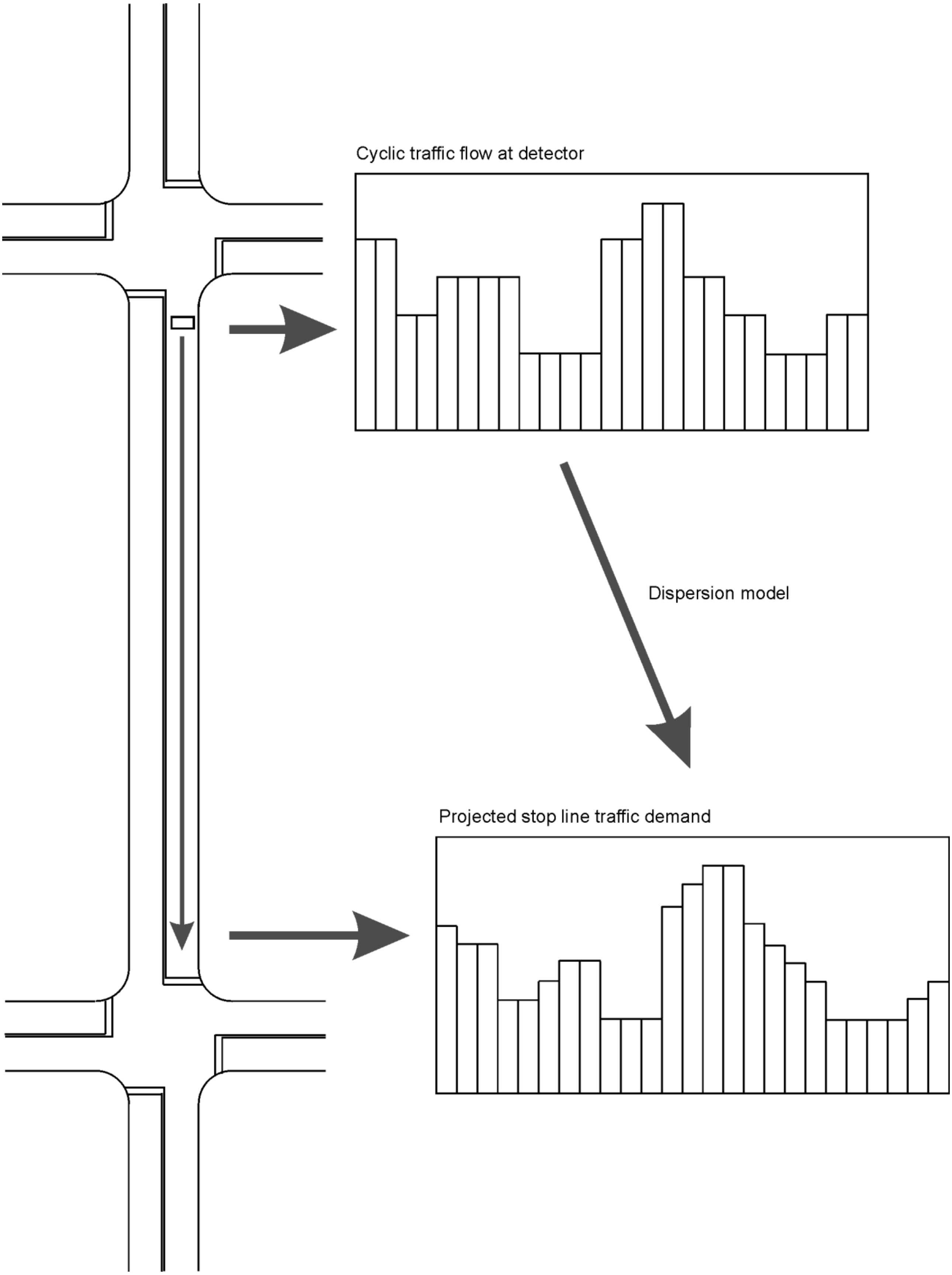

Figure 9.4: Projected traffic demand profile at downstream junction

6 The optimisation process is continued throughout the day. During low flow conditions, a shorter cycle length is used. The cycle length is increased gradually during periods of high traffic flow. Green splits are also adjusted based on flow patterns.

7 The SCOOT model requires a minimum number of basic parameters that are stored in a database. These parameters include the following:

(a) A network description in the form of nodes, links and detectors that must be coded according to prescribed rules. During this process, detectors are associated with links and links associated with downstream links and signal phases.

(b) The free-flow journey times from upstream detectors to downstream stop lines.

(c) The discharge rate from the stop line in Link Profile Units (LPU's). This is similar to saturation flow and is a critical parameter in the system that is determined during validation.

(d) Timetables which specify which signal plans should be operative and at what time of the day, day of week etc. Provision is usually made for a full year calendar to allow for public and school holidays.

8 On completion of the data preparation, a validation process is undertaken to ensure that the model accurately represents what is happening on the street network. Specific software is available to assist with this process. This should preferably be undertaken using a mobile computer and GSM connection to the instation computer. The importance of this validation process cannot be overemphasised.

9.6 BENEFITS OF ADAPTIVE AND RESPONSIVE SYSTEMS

1 There is a significant learning curve before systems such as SCATS and SCOOT can be used with confidence. Experience has, however, shown that the rewards in using these systems exceed the effort.

2 Field evaluations have shown that both systems can provide significant savings in fuel consumption, journey time and stops over and above conventional fixed time plans. These savings are further purported to increase significantly when compared with fixed time plans that have not been updated for a number of years.

3 Figure 9.5 shows the flexibility of traffic adaptive or responsive control compared to fixed time. There is a limit to the number of fixed time plans that can be developed, with the result that a plan must be utilised over a period of time during which the plan may not necessarily be optimal. In Figure 9.5, a total of six timing plans have been used over a period of 12 hours, and even these are not adequate to cope with the varying traffic demand. A traffic adaptive or responsive control system is able to respond to actual traffic demand in real time.

4 Definitive comparisons between SCOOT and SCATS have not been possible due to the divergent loop placement philosophies. Both systems provide positive benefits compared with fixed time operation and as is the case with many systems, both have their advantages and disadvantages.

5 Most cities in South Africa have opted for the SCOOT system. The need to share knowledge and experience with peers is an important motivation why preference can be given to the SCOOT system. However, when skilled manpower is available, there is no reason why the SCATS system or other systems cannot be considered.

9.7 DATA ACQUISITION BENEFITS

1 An added benefit of a traffic responsive system is the opportunity provided for acquiring traffic data for purposes other than traffic signal control. Due to the communication capabilities of such systems, it is also possible to collect traffic data in real time.

2 The data collected for the purposes of traffic responsive signal control are not perfectly accurate. It is, however, possible to develop adjustment factors based on traffic data collected by other means, such as automatic counting stations. These factors are used to improve the accuracy of the traffic data collected by the traffic responsive system.

3 The traffic data collected as part of the traffic signal control system can be utilised in a variety of applications. These applications are not only limited to those that are of value to the traffic engineer, but can also be of benefit to the public.

4 An important possible application for which such data can be utilised is the determination of congestion levels. The SCOOT system in fact allows for the direct estimation of vehicular delays at individual signals. Such information is available in real time and can form part of a driver information system in which information is provided on quickest available routes to destinations. Various methods of communication can be used for this purpose, such as computer networks or radio broadcasts.

5 The traffic data are useful in many traffic engineering applications outside traffic signal design. Such information can, for instance, be utilised for the production of traffic flow maps in which traffic volumes are indicated by bands of variable width. Such flow maps can be particularly useful in the overall planning of a road and street network.

6 The above data acquisition benefits of traffic responsive systems should be taken into account when a road authority is considering the introduction of such a system.

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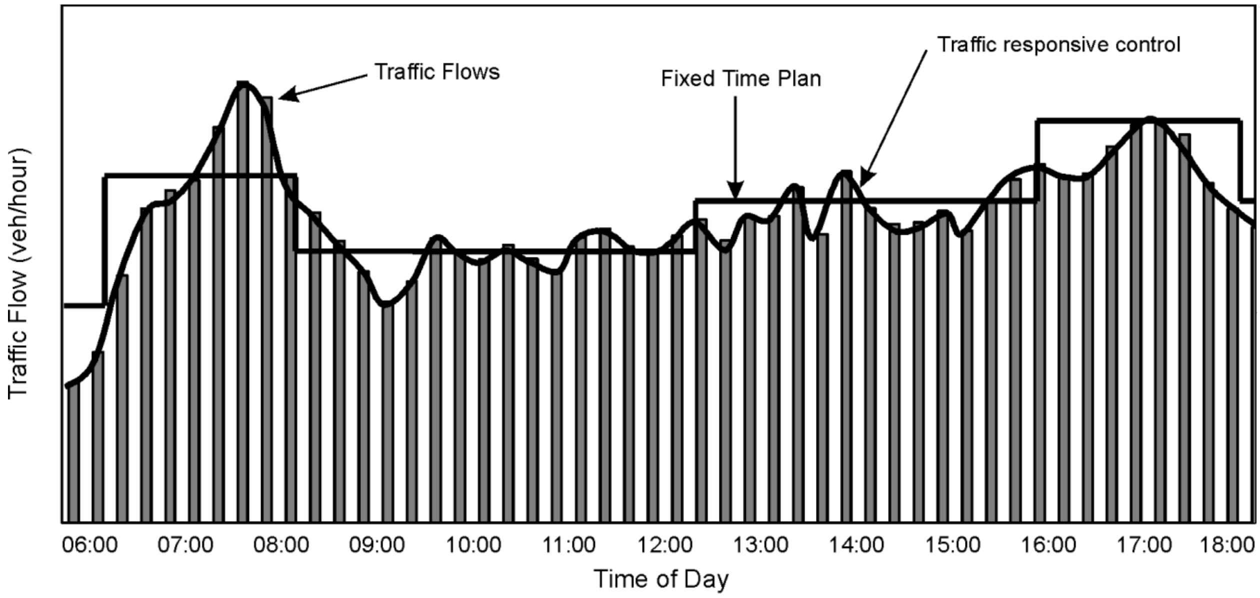


Figure 9.5: Flexibility of traffic responsive control

CHAPTER 10: VEHICLE PRIORITY

10.1 INTRODUCTION

1 Priority can be given at signalised junctions to certain classes of vehicles. These typically include emergency and public transport vehicles.

2 Emergency vehicles, such as fire engines and ambulances, can be given priority to reach areas of distress in the event of a major emergency. In such cases, a continuous band of green would be provided for emergency vehicles. For minor emergencies, these vehicles would typically use their sirens to obtain priority.

3 Public transport vehicles can be given priority when it is desired to make public transport more attractive to passengers by reducing travel time. Under priority control, buses could travel under green wave conditions, whether or not this applies to other vehicles on the same route. This enables them to more easily maintain their schedules and also to reduce travel times.

4 The provision of priority control must be justifiable through actual time savings that can be achieved. For public transport vehicles, such time savings should ideally be of such a magnitude that there would be a modal switch from passenger cars to public transport with a concomitant reduction in congestion.

5 Priority control does not require the use of special signals and can be applied to any configuration of signals at any junction. Use can, however, be made of bus or tram signals in situations where lanes are reserved for buses or tram rails are provided.

10.2 DETECTION OF VEHICLES

1 A major problem in the application of priority control is establishing the time of arrival at any given junction. The arrival time of buses, for instance, is determined primarily by the time spent by passengers boarding or alighting at bus stops. Their arrival at any given junction thus tends to be random and a fixed time type of control is correspondingly impossible to apply.

2 Priority control therefore requires the detection of vehicles as they are approaching a junction. This can be done by means of devices installed in (or alongside) the roadway or onboard the vehicles.

3 The devices that can be installed in the roadway include inductive loops, pneumatic pads, piezo-electric detectors, etc. The electronic “signatures” of vehicles are used to differentiate between different vehicle classes.

4 The more satisfactory method is onboard transponders for communication with a central control system. Use is made of an antenna that is either embedded in the road surface, or mounted alongside or above the road to detect priority vehicles. Information is relayed to a centralised computer, which initiates whatever priority action is contained within its algorithm.

5 Detectors or antennas have to be installed sufficiently far upstream to allow for initiation of the priority strategy. It follows that bus stops cannot be permitted between the site of the detector and the junction.

10.3 PRIORITY STRATEGIES

1 Various priority strategies can be considered. An example is to provide a green phase on the approach as soon as the priority vehicle is detected. However, this cannot be done immediately, and the normal sequence of yellow and all-red light signals must be provided on non-priority approaches. A “pre-emption” or “hurry call” facility must be available in the controller to implement this strategy.

2 If a priority vehicle is approaching a green light signal, priority would also involve providing a sufficiently long extension of the phase to allow the vehicle to safely clear the junction.

3 Pre-emption and priority control can also be exercised at non-junction locations such as at approaches to one-lane bridges, work sites and metered freeway on-ramp terminals.

4 Some of the above strategies can be provided in traffic responsive control strategies. For emergencies, some form of interaction would be required to initiate specific signalisation plans to cope with the emergency. Other strategies would be based on the automatic detection of priority vehicles.

CHAPTER 11: INDIVIDUAL VEHICLE CONTROL SIGNALS

11.1 OPERATION

1 Traffic signals for the control of individual or single vehicles, as distinct from those that give right of way to groups of vehicles, are used to control traffic at locations such as freeway on-ramps, toll booths and roadside checkpoints.

2 The Type S12 traffic signal face is used for the control of individual vehicles as shown in Figure 11.1. The signal face comprises only a RED DISC and a GREEN DISC LIGHT SIGNAL.

3 A yellow signal aspect is not provided in the S12 signal face. The signals should therefore not be used to control vehicles other than those that are stationary or travelling at low speed. This can be achieved by:

(a) displaying the green signal only to a vehicle that has already stopped at a stop sign, or other similar sign, near to the signal (such as at toll booths and checkpoints); or

(b) resting the signal in red and displaying the green signal ONLY when required, and then only for a few seconds to allow one stopped vehicle to depart at a time (such as when ramp metering is applied).

4 Where it is required to give continuous right of way to all approaching vehicles, the green light signal may be displayed continuously. When it is necessary to switch the signal to red, a flashing red light signal should first be displayed for a duration of at least 5 seconds.

5 At no time SHALL an operational traffic signal be intentionally switched off and blacked out, other than for maintenance or repairs or when controlled by a traffic officer or an authorised pointsman. Flashing red light signals may also be used to indicate that the signals are out of order.

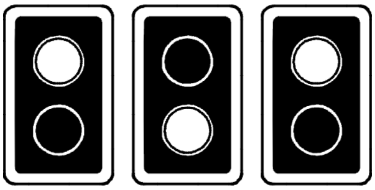


Figure 11.1: Single vehicle release operating sequence

11.2 TOLL BOOTHS AND CHECKPOINTS

1 The S12 traffic signal face is used at toll booths and checkpoints to instruct vehicles either to stop or to continue.

2 A STOP sign R1, or any other sign that instructs the driver to stop, should be displayed at the stopping point. At least one S12 traffic signal face should then be provided per lane of traffic, located on the right-hand (driver's) side of the lane. The signal face should be located not less than 6 m beyond the stop position.

3 The signal should wherever possible, be controlled automatically. The duration of the green light signal and change to red can best be controlled by the output from vehicle detectors in each lane. The illumination of the green light signal may be performed automatically, e.g. linked to a toll booth cash register, or manually.

11.3 RAMP METERING

11.3.1 General

1 Ramp metering is applied to restrict the number of vehicles allowed to enter a freeway in order to ensure an acceptable level of service on the freeway or that the capacity of the freeway is not exceeded. The need for ramp metering may arise due to factors such as:

(a) Recurring congestion because traffic demand exceeds the capacity of roads in an area.

(b) Sporadic congestion on isolated sections of a freeway because of short-term traffic loads from special events, often of a recreational nature.

(c) As part of an incident management system to assist in situations where an accident downstream of the entrance ramp causes a temporary drop in the capacity of the freeway.

2 Ramp metering should, however, be considered a last resort rather than a first option in securing an adequate level of service on the freeway. Prior to its implementation, all alternative means of improving the capacity of the freeway or reducing the traffic demand on the freeway should be explored.

3 Installation should be preceded by an engineering study of the physical and traffic conditions on the freeway facilities likely to be affected. These facilities include the ramps, the ramp terminals and the local streets likely to be affected by metering as well as the freeway sections involved.

4 The study should include the establishment of desirable metering rates. The effect of metering rates on the level of service on the freeway as well as the street network should be evaluated. Attention should be given to storage requirements on ramps and the possible impact of queues on local streets.

5 A problem with ramp metering is the need for law enforcement. Without enforcement, infringement rates can be expected to be high. If, for any reason, it is not possible to ensure regular enforcement, ramp metering should not be considered.

11.3.2 Installation

1 The stop line should be placed well in advance of the point at which ramp traffic will enter the freeway to allow vehicles to accelerate to approximately the operating speed of the freeway, as would normally be required for the design of on-ramps.

2 It will also be necessary to ensure that the ramp has adequate storage to accommodate the vehicles queuing upstream of the traffic signal.

3 The above requirement will almost certainly lead to a need for reconstruction of any ramp that is to be metered. The lengths of on-ramps are typically determined by the distance required to enable a vehicle to accelerate to freeway speeds. Without reconstruction, this could result in the ramp metering signal actually being installed at the ramp terminal.

4 A STOP LINE RTM1 shall be provided on the on-ramp. At least two S12 traffic signal faces should be provided for ramp metering at a distance not less than 6 m (preferably not less than 10 m) beyond the stop line.

5 A FLASHING YELLOW WARNING SIGNAL SS3 could, with advantage, be installed at the start of the ramp to warn vehicles that metering is in operation.

6 When ramp metering is in operation, the S1 signals should normally rest in red, and a green light signal displayed ONLY when required and then only for the time required by the departing vehicle to clear the line of vision of the signal face. Such timing should preferably be achieved by means of vehicle detectors. At least two detectors would normally be required for this purpose, namely the check-in and check-out detectors, as shown in Figure 11.2.

7 The check-in detector should be located at the position where vehicles would normally stop at the stop line. A long detector (up to 4 m or longer) would be required to cover a wide range of stopping positions. This check-in detector is used to actuate the green light signal when an approaching vehicle is detected AND a minimum red period has expired.

8 The check-out detector actuates the red light signal as soon as a vehicle is detected, subject to the provision of a minimum green period (from the time the vehicle is first detected and NOT when it departs from the loop). The detector must be located beyond the last traffic signal at a point where the red light signal will not be visible to the departing vehicle (about 1 to 2 m beyond the signal).

9 Detector loops can also be installed on the freeway itself to ensure that an adequate gap exists before the next green light signal is provided on the ramp.

10 A queue detector can also be used to identify the backup of traffic onto the local street system. When a queue of that length is detected, a higher metering rate may be temporarily allowed to reduce the queue to an acceptable length. This must, however, be applied with circumspection because a consistently high rate of arrivals may result in the application of a metering rate that is so high that it approaches the condition of there being, in fact, no metering at all - thus defeating the objective of installing metering in the first instance.

11 The highest rate of metering that can be handled by metering of a single stream of vehicles is approximately 900 vehicles per hour. This rate can be attained with about two seconds of green followed by two seconds of red. A red period shorter than 2 seconds should not be used.

12 A lower rate of metering can be achieved by increasing the minimum red interval. A metering rate in the order of 600 vehicles per hour will, for instance, be achieved by providing two seconds of green followed by four seconds of red.

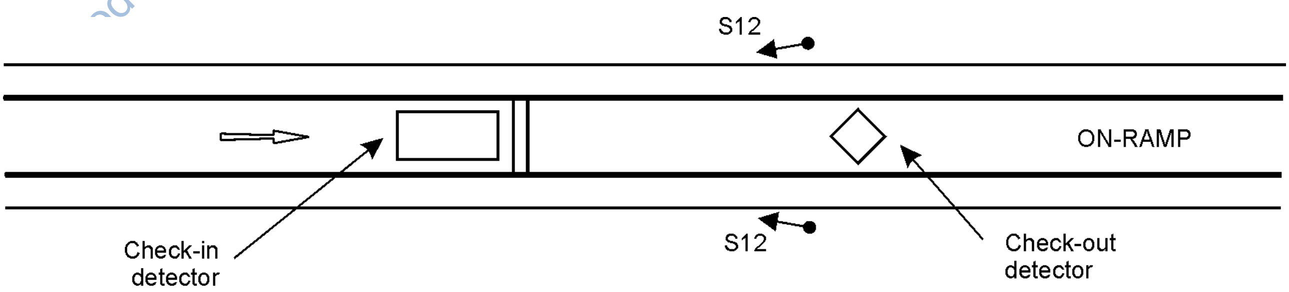


Figure 11.2: Ramp metering application of the S12 signal face

CHAPTER 12: SIGNALS AT ROADWORKS

12.1 INTRODUCTION

1 Temporary traffic signals may be provided at roadwork construction sites for the following purposes:

(a) to successively give right of way to two-way traffic approaching from opposite directions, along a single traffic lane, in place of a manually operated STOP-GO sign; or

(b) to control the movement of traffic, including site vehicles, where a public road enters or crosses a road that is under construction, or haul road; or

(c) as an interim measure to control traffic where a permanent traffic signal is to be provided, altered or replaced as part of a roadworks project.

2 Temporary traffic signals should be installed and operated only where warranted as follows:

(a) at a road junction or pedestrian crossing where traffic flow and delay conditions would otherwise warrant a permanent installation; or

(b) where there is undue delay or danger to public traffic at the junction of a public road and a road under construction or a haul road, as a result of construction operations, provided that the overall disbenefit to public traffic does not exceed the benefit to construction traffic; or

(c) where the control of two-way traffic on a single traffic lane is warranted; or

(d) where it would otherwise be necessary to exercise manual control by means of a STOP-GO sign during hours of darkness.

3 Temporary traffic signals should preferably not be operated for longer periods than 6 months. If required for longer than 6 months, the installation of permanent signals should be considered.

4 The principles of traffic signal control at permanent installations apply equally to temporary installations. This means that the numbers and locations of signal faces, the compulsory provision of background screens (backboards), sight distances, etc. also apply to temporary traffic signals. The speed limit at the traffic signals shall also not exceed a maximum of 80 km/h.

5 It is recommended that three yellow retro-reflective strips be provided on the signal posts and that white retro-reflective borders be used on backboards. Temporary traffic signals are often used in locations with poor background lighting and where they may be more subject to failure than permanent signals. The signals are also often used in locations where traffic signals would not normally be expected by drivers. It is therefore important that more attention should be given to the visibility of the signals.

6 Precaution should be taken to ensure the uninterrupted operation of the signals, by securing them against theft and vandalism, and by providing an effective power source. Lights and plant should wherever possible be securely anchored down and cables should be buried.

7 Warning signs should be provided in advance, but the signs should be concealed or removed while the signals are not operative.

8 Details of the use of temporary traffic signals at roadworks are given in Chapter 13 of Volume 2 of the Road Traffic Signs Manual.

12.2 VEHICLE-ACTUATED CONTROL

1 Depending on the anticipated traffic pattern, a manual or a vehicle-actuated traffic control signal with temporary actuation loops is likely to be more efficient than fixed time signals.

2 The operation of temporary vehicle-actuated signals at junctions does not differ significantly from that of permanently installed signals, and the same principles may be applied. The only difference would be in the use of temporary detection loops. Use can also be made of microwave detectors that do not require installation of loops in or on the road surface.

3 Vehicle-actuated control is particularly important in the control of two-way traffic on a single lane of traffic. Loops are not only needed on the approaches to such a lane, but can also be provided on the lane with the purpose of extending the all-red period just sufficiently for vehicles to clear the lane. This type of control is discussed below.

12.3 TWO-WAY TRAFFIC IN A SINGLE LANE AT ROADWORKS

12.3.1 General

1 Temporary traffic signals are often used for the control of two-way traffic in a single lane, particularly when the length of the lane is long. The signals are used to successively give right of way to the two-way traffic from opposite directions.

2 At least two traffic signal faces of type S1 shall be provided on a two-way single lane road at roadworks, one on each side of the road, at a position not less than 6 m (but preferably not less than 10 m) beyond the stop line RTM1. However, where the traffic signal is manually operated, only one such signal face may be provided.

3 The stop line must be suitably located on the wider part of the road so that opposing traffic can pass vehicles waiting at the stop line.

4 Portable equipment may be used in the signal installations. At least two sets of traffic signals will be required, each set consisting of:

(a) Signal faces mounted on a yellow post, fitted with backboards (preferably with retro-reflective borders and strips).

(b) A signal controller, equipped with a radio module, and if necessary a manual remote control unit.

(c) A set of vehicle detectors (preferably microwave detectors).

(d) Power pack of batteries and/or generator.

(e) Spare equipment, particularly spare lamps.

5 The controller may allow for two-phase operation only. Each side of the lane has a separate controller, one of which must be switched to “master” operation and the other to “slave” operation. The controller must provide that, in the event of failure or a loss in radio communications, the signals revert to flashing red mode.

6 Vehicles can be detected by means of temporary induction loops, but microwave detectors could be more appropriate. Detectors can be installed on the approaches to the single lane, and also on the lane itself. Detectors on the approaches are used for the extension of the green interval and the detection of demand, while detectors on the lane itself may be used for adjusting (extending) the all-red interval.

7 When the signals are located relatively close together, a cable may be used to link the two controllers. In cases where the two signals are spaced very close together, one controller can be used to drive both sets of signals.

8 Where the signals are located further apart, radio communication would be the more desirable method of linking the two controllers. Care should be taken that such a radio would be able to communicate reliably over the distances required.

12.3.2 Manual operations

1 The traffic signals may be operated in manual mode. For such operations, a remote control unit should preferably be provided. This remote unit can be connected to the signal controller with a cable. The use of the remote unit allows the operator to be located safely in a position where the approach is clearly visible (but preferably in a position where both approaches are visible).

2 In manual mode, the operator controls the duration of all-red and green intervals, but not that of the yellow interval that is predetermined. Minimum periods may be set for the green and all-red intervals. The controller must prevent green accidentally being displayed in both directions.

3 The operator should view both approaches and switch the signals accordingly. When this is not possible, an assistant should be provided who is in radio contact with the operator. This assistant will inform the operator when vehicles are approaching or waiting to be served at the other end of the single lane, and when the queue of vehicles has departed from the approach.

4 The operator should provide only sufficient green for the waiting queue of vehicles to depart from the signal, except when there is no demand at the other end of the single lane. An adequate all-red period must be provided to allow the last vehicle to exit from the single lane.

5 In the absence of traffic demand on any of the approaches, the operator should rest the signal in all-red. This will allow a green light signal to be provided soon after a vehicle has arrived on either side of the single lane.

12.3.3 Fixed time operations

1 In fixed time operation, green and all-red intervals are predetermined and there is no response to vehicle demands. This type of operation is not very efficient, but it has the advantage that it is less costly to operate and maintain.

2 In fixed time mode, the maximum 15-minute traffic demand that is likely to occur must be established and sufficient green provided. The duration of the green intervals can be established as for a normal fixed time controlled junction, except that a longer all-red period is provided.

3 The all-red interval should provide sufficient duration for slow moving traffic to clear the single lane before the onset of the opposing green. This should be established based on the 15th percentile free-flow speed on the lane (judgement may be required to establish whether this would be adequate). The all-red period may not be less than 2 seconds.

4 When sufficient sight distance is provided, a shorter all-red may be used, and a flashing red light signal provided to indicate that drivers can proceed after stopping if the way ahead is clear.

12.3.4 Vehicle-actuated operations

1 Vehicle-actuated operations allow signals to automatically respond to vehicle demands. The signals will change in response to the registered demand as vehicles actuated the detectors.

2 The vehicle-actuated controller will only provide green until a gap is detected on the approach, and a demand has been registered on the other side of the single lane. When a gap is detected, the signal will change to the next phase, subject to the provision of minimum green intervals.

3 Vehicle detectors can also be provided on the lane itself, which will allow for the adjustment (extension) of the all-red interval. These detectors should be spaced at constant distances, and an extension time provided which will allow a vehicle travelling at the 15th percentile speed to reach the next detector (and finally the stop line) within the extension time provided. A minimum all-red period equal to this extension time must be provided to allow departing vehicles to reach the first detector along the single lane. Extensions must be provided for both directions of movement.

4 The adjustment of the all-red interval can significantly reduce unnecessary delays when roadworks occur over long distances. Assuming a 15th percentile speed of about 12,5 m/s (45 km/h), a single lane of 1 km would require an all-red interval of about 80 seconds (1000 m/12,5 m/s = 80 s). If the last vehicle departing from green travels at a higher speed of 20 m/s (72 km/h), only 50 seconds of travel time would be required. This would mean that vehicles would be waiting unnecessarily at the other side for 30 seconds while all vehicles have already cleared the lane.

5 Suppose three extension detectors are provided along the lane at 250 m distance intervals. This would require an all-red extension time of 20 seconds (250 m/12,5 m/s = 20 seconds).

6 A minimum all-red period of 20 seconds is provided on termination of green. If the last vehicle to depart is travelling at a speed of 20 m/s, this vehicle would reach the first detector after 12,5 seconds, or 7,5 seconds ahead of the minimum all-red period. The first detector extends the all-red period by 20 seconds to a total of 12,5+20 = 32,5 seconds.

7 The vehicle reaches the second detector 25 seconds after it had left the stop line. The all-red period is extended by 20 seconds to a total of 25+20=45 seconds. At the third and last detector, the all-red period is be extended to the final total value of 37,5+20 = 57,5 seconds.

8 The vehicle travelling at 20 m/s will be exiting from the lane after 50 seconds. This then means that vehicles will only wait unnecessarily for about 7,5 seconds, which is significantly less than the 30 seconds without detectors.

9 The above delays are directly related to the length of the single lane. A single lane of 2 km would double the delays, while a lane of 10 km would cause 10 times as much delay.

10 In the absence of any demand, the signals should revert to all-red, until a vehicle is detected. This feature ensures that the signals are then able to give right of way to the first approaching vehicle with minimum delay. This is a further important advantage of vehicle-actuated control.

CHAPTER 13: LANE DIRECTION CONTROL SIGNALS

13.1 INTRODUCTION

1 Lane direction control signals are used to signalise reversal of traffic flow along a road lane to accommodate the tidal nature of traffic flow during different times of a day. The signals shall be used to *indicate the permitted direction of traffic movement along a lane of a road and to prohibit the entry of traffic into, and the movement of traffic along, that lane from the opposite direction*. In this way, right of way can be allocated alternately on a predetermined basis, to one of two possible directions of traffic movement in the lane, or lanes, so signalised.

2 Lane direction control signals shall ONLY be used to permit or prohibit traffic movements in situations where *at least one lane is subject to reversals* of the direction of traffic flow. If there is a need for such application, use can be made of VARIABLE MESSAGE SIGNS as described in Chapter 9 of Volume 1 of the Road Traffic Signs Manual.

3 The signal faces that may be used for lane direction control are the S16, S17, S18 and S19 signals shown in Figure 13.1. Permitted variants of the S16 and S17 signal faces are shown in Figure 13.2. The variants S(16)-17 and S16-(17) may be provided as variable signals where both the cross and arrow can be displayed on a single matrix.

4 According to the National Road Traffic Regulations, the STEADY GREEN DOWNWARD-POINTING ARROW SIGNAL S16 is used to ***"indicate to the driver of a vehicle that he or she may drive his or her vehicle in the lane over which the arrow is displayed"***.

5 The STEADY RED CROSS SIGNAL S17 is used to ***"indicate to the driver of a vehicle that he or she shall not drive his or her vehicle in the lane over which the cross is displayed and that the lane is open to vehicles travelling in the opposite direction"***.

6 The YELLOW LEFT AND RIGHT ARROW SIGNALS S18 and S19 are used to ***"indicate to the driver of a vehicle that the lane over which the arrow is displayed is closed ahead and that he or she shall leave the lane in the direction of the arrow when it is safe to do so"***.

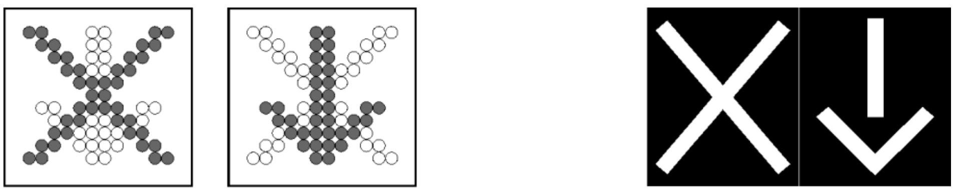
13.2 INSTALLATION

1 LANE DIRECTION CONTROL SIGNALS shall comprise of two independently illuminated signal aspects, Types S16, and S17. The signals SHALL be mounted in PAIRS as shown in Figure 13.3, one facing in each direction, centrally over the traffic lane subject to reversal in direction of use.

2 PAIRS of the lane direction control signals S16 and S17 shall be placed at the beginning and end of each lane subject to reversed flow and at intermediate points along the lane that will enable a driver to see at least two light signals at any time, the distance apart not exceeding half the minimum sight distance for urban conditions given in Table 3.1 of Chapter 3 of this manual (Volume 3).

S17 Red Cross | S16 Green Arrow | S18 Yellow Arrow (left) | S19 Yellow Arrow (right)

Figure 13.1: Standard lane direction control signals



Red Cross Display S(16)-17 | Green Arrow Display S16-(17) | S16-17

Figure 13.2: Permitted variants of lane direction control signals

3 It is recommended that fixed display lane direction control signals, or fixed "arrow" or "cross" signs, be placed over all OTHER lanes that are not subject to reversible traffic flow, to supplement the LANE DIRECTION CONTROL SIGNALS.

4 LANE DIRECTION CONTROL SIGNALS S18 or S19 may be placed in advance of the lane closure, over the centre of the lane to be closed. Signals S18 or S19 shall be operated on the basis that they are either illuminated or switched off. The signals shall be illuminated when they precede an illuminated S17 RED CROSS signal over the reversible flow lane. If it is necessary to provide a long merging distance, more than one S18 or S19 signal may be used, in sequence, over the approach lane. These signals do not have to be mounted in pairs.

5 The roadway signals S18 or S19 should be located in advance of the lane closure at a distance as given in Table 3.1 in Chapter 3 of Volume 1 of the Road Traffic Signs Manual. This distance should be increased in accordance with the difficulty which traffic may experience in merging with traffic in the adjacent lane.

6 The lane direction control signal faces are normally gantry mounted and the standards for height and clearance are the same as for other signals. The faces may NOT be mounted with the centre of the signal aspects at a height exceeding 6,2 m above the road. There shall also be a vertical clearance of not less than 5,2 m from the road to the lowest part of any light assembly or supporting structure.

7 Light units in South Africa shall conform to the requirements of South African standard specification SANS 1459: *Traffic lights* in regard to light output and colour value of light signals. Details of the light signals, including dimensions, are given in Chapter 10 of Volume 4 of the Road Traffic Signs Manual.

8 Appropriate lane markings, as described in Chapter 7 of Volume 1 of the Road Traffic Signs Manual may be used.

13.3 OPERATION

1 Reversal of the direction of traffic flow along a road lane, or lanes, can be considered where it is beneficial to make use of the tidal nature of traffic flow. Such traffic flow reversals, however, shall be used only where it can be certain that it will operate safely. The technique is not recommended for use on roads with a speed limit exceeding 80 km/h.

2 Careful attention should be given to capacity requirements and channelisation of traffic at each end of the lane(s) subjected to reversed traffic flows. Inadequate capacity to meet the increased directional flow will mitigate against the effectiveness of the action. Some drivers may get confused as to which lanes to use at the terminal points and extra control signals or other measures may be needed at these locations.

3 Traffic flow in any one direction shall be for continuous periods of not less than one hour. Changeover should preferably occur at the same time of each day of the week and when traffic volumes are not at, or near, the peak. It is recommended that there should be no more than two changeovers in one day, i.e. one period of reversed flow per day.

4 Prior to permitting vehicles to use a reversible direction lane, all the signals along each section shall show crosses in both directions to provide sufficient time to ensure that the traffic lane is free of moving or trapped vehicles.

5 Signals may be switched off when not required, provided that in such circumstances the direction of flow of traffic and the bounds of traffic lanes are obvious from other permanent road traffic signs.

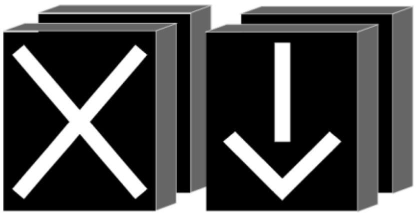


Figure 13.3: Back-to-back mounting of lane direction control signals

CHAPTER 14: RAILWAY CROSSING SIGNALS

14.1 INTRODUCTION

1 The National Road Traffic Act permits the railway operator (Transnet Limited) to erect road traffic signs at railway crossings as they may deem expedient. However, provision is also made in the act that such operator can be directed to display or remove signs as may be required.

2 According to the National Road Traffic Regulations, no person shall stop a vehicle on the roadway of a public road within the railway reserve at a level crossing, except in order to avoid an accident, or in compliance with a road traffic sign or with a direction given by a traffic officer.

3 Due to extremely high risk of fatal and serious injury resulting from accidents at level railway crossings, it is important that the highest standard of traffic control should be provided at such crossings. This includes making drivers aware of the fact that they are approaching a level railway crossing.

4 Railway crossings should be marked with the rail crossing warning signs W403 or W404. Sign W403 is displayed on approaches to single railway level crossings, while sign W404 is displayed on approaches to level crossings with more than one railway line. In addition to these signs, the advance warning sign W318 can be applied with good effect, particularly under circumstances where visibility is obscured. These signs and their applications are described in Volume 1 of the Road Traffic Signs Manual.

5 A number of road signs may be used for the control of traffic at level railway crossings. These include the use of FLAG SIGNALS SS2 as well as STOP SIGNS R1 and YIELD SIGNS R2 singly or in combination with the W403 or W404 warning signs. The use of these road signs is described in Chapter 7 of Volume 2 of the Road Traffic Signs Manual.

6 FLASHING RED DISC LIGHT SIGNALS (FRD) may also be used to warn drivers that a train is approaching a level crossing. Two such signals shall be used in conjunction with a STOP SIGN R1 and a warning sign W403 or W404. The signals shall be mounted below the stop sign R1 and above the warning signs W403 or W405 as shown in Figure 14.1.

7 According to the National Road Traffic Regulations, the flashing red disc signal ***“indicates to the driver of a vehicle that he or she shall stop his or her vehicle and shall not proceed until it is safe to do so, and such signal shall have the same significance as stop sign R1”***.

14.2 INSTALLATION

1 The flashing red light signals at railway crossings SHALL be situated on the near side of the railway crossing, on the left side of each approach roadway.

2 The flashing red light signals shall conform in all respects to the requirements laid down for vehicular traffic signals at road junctions and pedestrian crossings, except that:

(a) The signal face shall comprise a single red disc aspect and shall be mounted on the same post as the stop signs R1 and the warning signs W403 or W404.

(b) The red disc aspect shall be displayed only in flashing mode, as and when required to warn of the approach or presence of a train, and shall not display a steady red light signal at any time.

(c) Two flashing red disc signal aspects shall be provided on the same post.

(d) The flashing red disc signal may be accompanied by an audible signal.

(e) The signal posts shall be as for road signs.

Figure 14.1: Flashing red disc light signals at railway crossings

3 In South Africa, the signals shall comply with standard specification SANS 1459: *Traffic lights*.

4 The use of flashing red disc light signals will be warranted by one or more of the following conditions:

(a) when a crossing has a high accident history;

(b) sight distance requirements are not met (these requirements are given in Chapter 2 of Volume 2 of the Road Traffic Signs Manual);

(c) train operations involve reversals of movement across the crossing; or

(d) train operations occur during the hours of darkness.

14.3 OPERATION

1 The two flashing red light signals are used to indicate to a driver that he or she shall stop his or her vehicle. The preferred mode of operation is that a flashing red disc light signal is displayed at least 30 seconds before the arrival of a train. If gates or barriers protect the crossing, the flashing red light signal should start 20 seconds before the gate or barrier closes.

2 The two flashing red disc light signals shall be arranged to flash alternately in such a way that the alternating flashes remain constantly out of phase i.e. when one disc is fully illuminated the other disc has zero luminous intensity and vice versa.

CHAPTER 15: HAND AND OTHER SIGNALS

15.1 GENERAL

1 This section covers a number of traffic signals that involve manual indications or other signals that are no operated electrically, and include the following:

(a) control hand signals for use by traffic officers SS1;

(b) flag signals SS2;

(c) flashing yellow warning signals SS3; and

(d) flare signals SS4.

15.2 CONTROL HAND SIGNALS FOR USE BY TRAFFIC OFFICERS SS1

15.2.1 General

1 CONTROL HAND SIGNALS FOR USE BY TRAFFIC OFFICERS SS1 may be used to control the movement of traffic and/or pedestrians and as such are regulatory signals. Such signals will normally be used when some other form of traffic control is out of operation or when traffic volumes are such that special control needs to be exercised to reduce congestion and establish order, or when there is a need to stop traffic for a specific reason.

2 According to the National Road Traffic Regulations, ***"a control hand signal SS1 shall conform to the requirements of one of the standard hand signals*** as shown in Figure 15.1 ***and shall be:***

(a) ***a hand signal to stop traffic approaching from the front, indicating to the driver of a vehicle approaching a traffic officer from the front, who is displaying the signal, that he or she shall stop until the signal referred to in d) below is displayed;***

(b) ***a hand signal to stop traffic approaching from the rear, indicating to the driver of a vehicle approaching a traffic officer from the rear who is displaying the signal, that he or she shall stop until the signal referred to in d) below is displayed;***

(c) ***a hand signal to stop traffic approaching from the front and the rear, indicating to the driver of a vehicle approaching a traffic officer from the front or rear who is displaying the signal, that he or she shall stop until the signal referred to in d) below is displayed; or***

(d) ***a hand signal to show traffic to proceed from the front, left or right, indicating to the driver of a vehicle that he or she may proceed if a traffic officer displays the signal"***.

3 In addition to the above hand signals, the traffic officer may use other hand signals to supplement those described above. It is common practice, for instance, for a traffic officer to select the vehicle that he or she wishes to stop some distance back in a traffic stream and to clearly identify it by pointing prior to giving the appropriate hand signal. In a similar way, a traffic officer may indicate by pointing to one of several stopped streams of traffic that the vehicles in the indicated stream may proceed.

4 Having given a stop signal to road users the traffic officer may lower the hand used for such signal and uses it to execute other hand signals. The road users stopped by such original signal shall not proceed until directed to do so by the traffic officer.

5 When dealing with complex traffic movements it may be necessary for a traffic officer to give signals that combine more than one of the elements of those described above. For example, when directing turning traffic, it may be necessary for the traffic officer to cut off traffic flow from the left by holding his extended arm at 90 degrees to his body instead of parallel to his body.

6 A traffic officer using hand signals should be positioned within the junction in a position most visible from all approaches and as close as possible to the centre of the junction, subject to paths of the vehicles that are permitted to enter the junction at any given time.

15.2.2 Point control of junctions

1 Traffic officers or authorised pointsmen are often used for the control of traffic at junctions during peak periods. A traffic officer or pointsman may also intervene with the operations of traffic signals.

2 It is possible to achieve very efficient traffic operations with point control at isolated junctions. In a network of traffic signals, this is more difficult, if not impossible to achieve.

3 The basic objective of point control of an isolated junction is to keep the junction as busy as possible and to eliminate all lost time. Only queues of vehicles should be allowed to discharge from one or more approaches, after which priority should revert as soon as possible to other waiting queues.

4 Where possible, a discharging queue should not be stopped since any overflow of vehicles would increase delay. If sufficient time is not provided for such a queue to discharge, the queue will grow indefinitely, causing excessive delay to traffic.

5 However, giving too long a period of right of way to one or more approaches, would result in lost efficiency every time departure flow rate drops below the maximum possible departure flow rate. The delay experienced by stopped vehicles increases while approaches from which vehicles depart are operating at low levels of efficiency.

6 The objective of an efficient point control strategy, therefore, is to switch right of way as soon as the queue of vehicles has departed from an approach (but only if there are vehicles waiting in other queues). This, however, is subject to limits since right of way cannot continuously be provided to one stream of traffic while other vehicles are experiencing long delays. Right of way should not be given to one stream for longer than approximately 1 minute.

15.3 FLAG SIGNALS SS2

1 FLAG SIGNALS SS2 may also be used to control the movement of traffic, and as such are regulatory signals. Such signals will generally be used at roadworks and for the control of traffic during sporting and other events. It is particularly appropriate for small and mobile works where flags may also be combined with road signs and/or construction vehicles.

2 According to the National Road Traffic Regulations, ***"a flag signal SS2 shall conform to the requirements of the flag signals*** *shown in Figure 15.2* ***and shall be:***

(a) ***a flag signal to stop, indicating to the driver of a vehicle that he or she shall stop until the flag signal referred to in b) below is displayed; and***

(b) ***a flag signal to proceed indicating to the driver that he or she shall proceed when the flag signal is displayed"***.

3 A WARNING FLAG SIGNAL may also be used to warn a road user to proceed slowly, and be alert of a hazard in or adjacent to the roadway ahead.

4 A good, active flagman can be as effective as any other means of drawing attention to a hazard in the roadway. The reason for this is that the flag movement makes a very effective visual target in the field of view of the driver. A good flagman will also make sure that a driver is aware of the signal.

5 Innovative techniques may also be employed with a warning flag signal to good effect. A flagman may, for instance, stand at a particularly important road sign and point to it with a second flag.

6 Flagmen should be chosen for their general alertness, good eyesight, hearing, and an adequate ability to communicate in a pleasant manner with the driving public. It must be realised, however, that the task of flagging is a boring one. Flagmen should therefore be organised into rosters and should be alternated at regular intervals.

7 The careful training of flagmen is essential before making them responsible for the flow of traffic. The efficiency of flag control is often dependent on their training.

8 Flagmen should wear conspicuous and distinctive clothing such as fluorescent-coloured helmets, bright coloured overalls together with a safety vest or jacket utilising retro-reflective and/or fluorescent panels in red, yellow, and/or white.

9 Flagmen should be located well in advance of the hazard to which attention is being drawn. This distance should at least provide sufficient time for vehicles to slow down before reaching the hazardous location, but not at such a distance that drivers will tend to increase speed. The flagman should stand in a very visible position.

10 The flagman should either stand on the shoulder adjacent to the lane of traffic they are controlling or in a barricaded lane. Under no circumstances should they stand in the traffic lane. The flagman should stand alone, and nobody should be allowed to gather around the flagman.

11 In many circumstances, the function of the flagman is to draw attention to other temporary road traffic signs. He or she will therefore commonly be located at the beginning of an advance sign sequence where traffic is moving at high approach speeds. Flagmen may also be used within a roadwork site to draw attention to a specific localised hazard.

12 FLAG warning signals SS2 should be square with a minimum side length of 450 mm. A side length of 600 mm is preferred for high-speed approaches (70 km/h or higher) or high traffic volumes. FLAGS should be made of a bright red or red-orange material attached to a staff approximately 1 m in length. The free edge, and if necessary the diagonal of the flag may be stiffened to maximise the visible area. However, such stiffening should not remove all capability of the flag to be waved. Retro-reflective and/or fluorescent materials are recommended. Flags shall be kept clean at all times.

13 Additional details on the use of flag signals and flagmen are given in Chapter 13 of Volume 2 of the Road Traffic Signs Manual.

15.4 FLASHING YELLOW WARNING SIGNALS SS3

1 The FLASHING YELLOW WARNING SIGNAL SS3 may be used to warn a road user of the presence of a particular hazard or traffic control device. Signal SS3 may be combined with REGULATORY or WARNING signs as illustrated in Figure 15.3, and it forms part of an emergency flashing light warning sign W346 or TW346.

2 The signal light shall conform in all respects to the requirements for a traffic light signal and, in South Africa, conform to the South African standard specification SANS 1459: *Traffic lights*. The exceptions are as follows:

(a) The light signal shall be used to display a FLASHING YELLOW DISC LIGHT SIGNAL only, and shall not be used to display a steady light signal.

(b) No other light signal shall be displayed at, or alongside, the flashing yellow warning signal.

(c) Duplicate light signals, up to a maximum of four, may be provided at one sign and these may flash alternately.

(d) Signal posts shall be as for road signs.

3 Whilst the signal should be conspicuous, it shall not obscure the sign or distract attention from it. The brightness of the signal should not cause "discomfort glare" or "disability glare", particularly at night. If necessary, provision should be made to reduce the luminous intensity of light signals automatically during the hours of darkness.

4 The signal may be operated 24 hours every day, or intermittently, as required. Intermittent operation may be achieved by means of a time switch, or by an external input, for example, upon the actuation of a pedestrian push button at a pedestrian crossing.

5 It is recommended that flashing yellow warning signals should only be used in conjunction with road signs. The installation and operation of a flashing yellow warning signal is warranted where hazardous conditions exist on the road and/or it is necessary to draw attention to a road sign and reinforce its effect. If the signal can be warranted, an appropriate road sign must similarly be warranted. The road sign will indicate to drivers the specific nature of the hazard which the flashing signal cannot do. Installations shall be permanent except at roadworks where flashing yellow warning signals may be used with any of the prescribed temporary warning signs.

6 Single flashing yellow warning signals can only be used with warning signs where it is necessary to draw attention to the warning sign and reinforce its effect.

7 Two or four flashing yellow warning signals may be used with any road sign, but the arrangement and brightness of the signal should not detract attention from the sign or cause disability glare. The signals should flash alternately (singly on in pairs) and not randomly.

8 Flashing signals shall operate at a frequency of between one and two flashes per second and the luminous intensity shall be zero for 30% - 50% of the period and not less than the specified minimum for 30% - 50% of the period.

15.5 FLARE SIGNALS SS4

1 The FLARE warning signal SS4 may be used to warn the road user of a temporary hazard in the roadway ahead and to indicate that they should reduce speed immediately.

2 Road safety flare signals SS4 are temporary devices with a high visual impact which may be used as an "immediate action" device by traffic officers attending the scene of a collision or other incident which affects the use of all or a portion of a roadway. Such flare signals should emit a red or red/orange light and moderate smoke. Flare signals permit traffic officers to deal speedily with any life threatening aspects of the incident before giving more detailed attention to traffic control.

3 It is recommended that two flares be used at any location. These should be placed well in advance of the incident site. As a guideline the first flare should be located a distance 2xD metres in advance, where "D" is the speed limit in km/h. The second flare should be located at a similar distance in advance of the first flare.

4 Before setting out flare signals the following checks should be carried out:

(a) Does the incident involve any hazardous/ inflammable materials?

(b) If it does, can these drain in the direction of the flares?

(c) Is the roadside vegetation, in combination with the wind a fire risk?

(d) Can the flare signal be made safe from falling over or rolling in the prevailing wind?

FLARE signals shall not be held in the hand, or waved in the air.

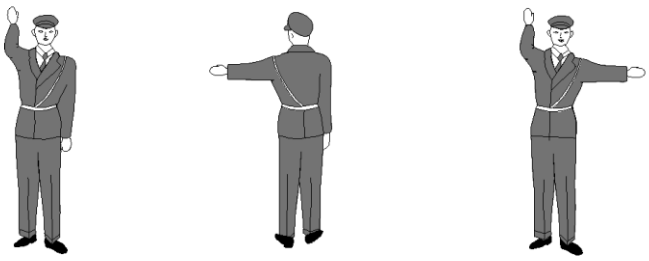


Figure 15.1: Control hand signals for use by traffic officers SS1

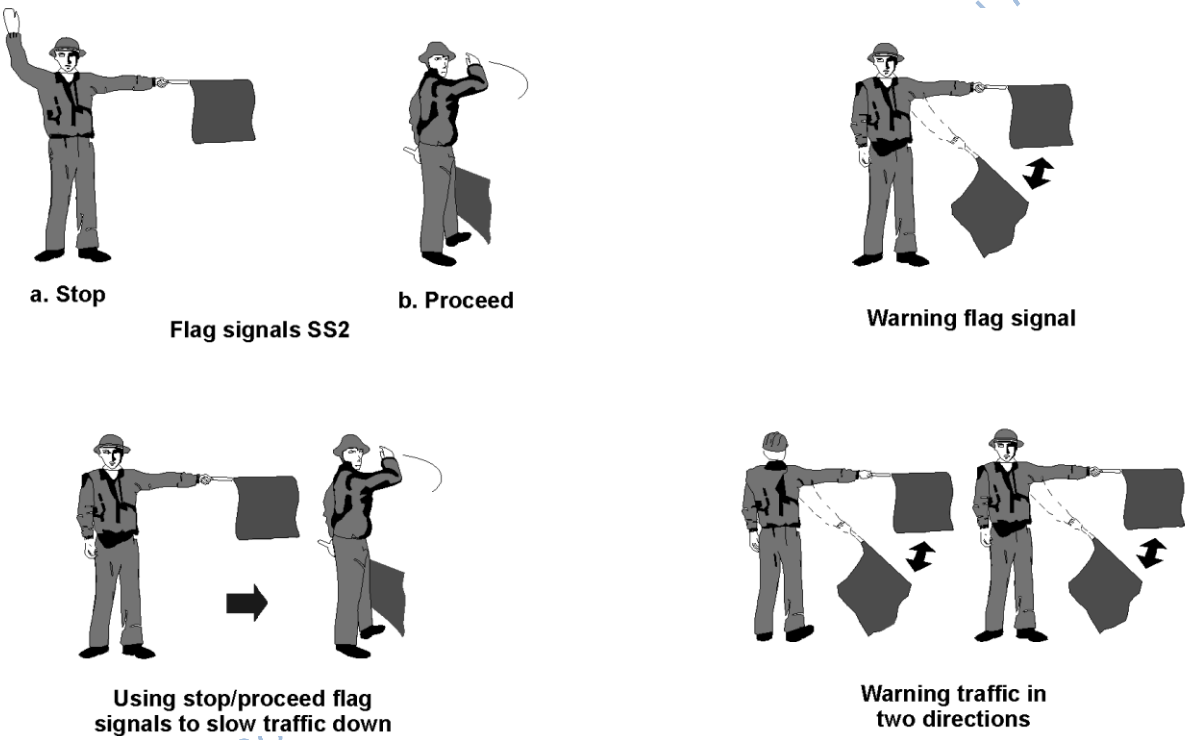


Figure 15.2: Flag signals SS2

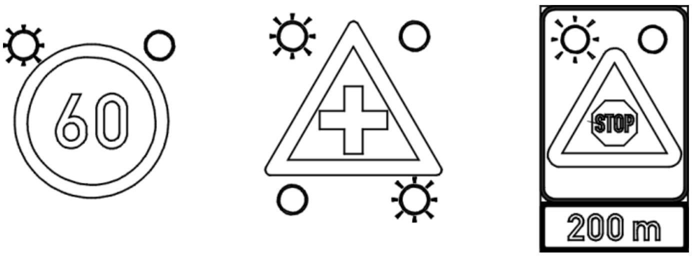


Figure 15.3: Flashing yellow warning signals SS3

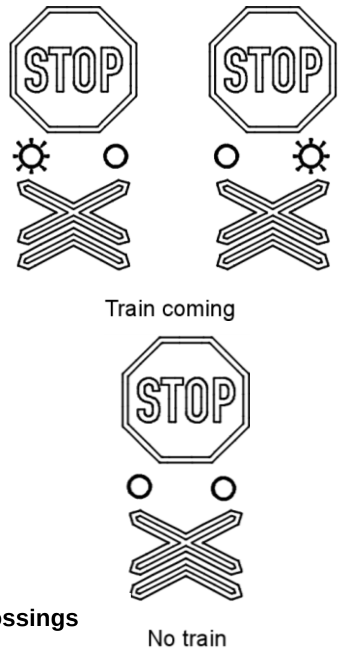


Figure 15.4: Flashing red disc light signals at railway crossings