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RTA 08.092

Standard

Traffic Signal Design

Part 3: Level Crossing Interface

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Document history

Revision	Effective date	Summary of changes
1.0	01/06/2010	First issue as RTA 08.092
1.0	18/12/2025	First issue as TS 02670.3 This document supersedes TS 02670 (Parts 22 and 23) (RTA 08.092) *Traffic signal design* Changes include revision of requirements; traffic signal terminology; removal of outdated and unnecessary content.

Preface

This Standard is the first issue as TS 02670.3 and supersedes RTA 08.092, *Traffic Signal Design* (parts 22 and 23).

This document sets out to provide consolidated design guidance and requirements for signalised intersections at level crossings. It is inclusive of multi-modal transport across active transport, roads and heavy rail.

It is complimentary to the suite of road and rail design guidelines and standards across applicable state and national levels.

Designers should also exercise discretion and engineering judgement in developing the design of traffic signals at a particular site.

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1 Scope

This standard sets out requirements and guidelines for traffic signal design and interface with level crossings, both new and modified installations, including temporary installations. It aims to promote best practice and consistency for traffic signal design across various contexts.

The requirements in this document cover the following key areas of traffic signal design:

- coordination and operation
- signal phasing
- software configuration.

2 Application

This document applies to all public roads (both metropolitan and non-metropolitan) as defined by the *Roads Act 1993* (NSW).

The traffic signal design process detailed in this document applies at the Plan, Create/Acquire and Operate/Maintain stages of the TfNSW asset life cycle.

The content applies to the design and operate stages of traffic signals interfaced with a level crossing. It details their coordination principles, phasing, time setting and calculations. The intended audience is designers, design approvers and operators.

3 Referenced documents

Australian standards

AS 1742.7 *Manual of uniform traffic control devices Part 7: Railway crossings*

Transport for NSW standards

TS 02642 *Supplement to Austroads Guide to Road design*

TS 02670.1 (RTA/PUB 08.092) *Traffic Signal Design Part 1: Investigation and approvals*

TS 02670.2 (RTA/PUB 08.092) *Traffic Signal Design Part 2: Design principles*

TS 05317 (TMG A1620) *Level Crossing – Traffic Signal Design Interface Agreement*

TS 05333.18 (T HR SC 10018) *Signalling Design Principle – Level Crossings*

TS 05493 (RTA-TC-106) *Traffic Signal Operation*

TS 06328.1 (LX-SP-001) *Level Crossing Interface – Railway Interface Unit Design*

TS 06328.2 (LX-IP-001) *Level Crossing Interface – Railway Interface Unit Installation and Testing*

TfNSW Drawings

TS 06466 (VE516-57) *Traffic Signal Controller Railway Interface Unit Circuit Diagram*

Legislation

Roads Act 1993 (NSW)

Other referenced documents

Austroads AGRD04 *Guide to Road Design Part 4: Intersections and Crossings – General*

Gipps, P.G., 1981. "*A behavioural car-following model for computer simulation*," Transportation Research Part B: Methodological, Elsevier, vol. 15(2), pages 105-111, April.

4 Terms, definitions and abbreviations

The following terms, definitions and abbreviations apply in this document.

active level crossing railway crossing equipped with flashing lights, audible warning devices and boom barriers, which are normally controlled entirely by the approach of a train

all-red interval for the clearance of traffic within the controlled areas, during which red is displayed to all approaches

clearance phase phase to allow vehicles that may be trapped on a level crossing to proceed clear of it

controller personality data unique to a particular traffic control signal which is read and interpreted by the background software to enable the site to operate; this provides details including the number of phases, the number of pedestrian movements, the number of signal groups and signal group operation

ECG early cut-off green phase; interval that allows some signal groups to be terminated before others in the same phase

green interval when the related movement is operating

interval (phase) one of five sequential time periods within the running part of a phase or three sequential time periods within the clearance part of a phase

MFC marked foot crossing; transverse line marking consisting of two parallel pedestrian crosswalk lines; may refer to either footpath or shared path crossing

MSS miscellaneous status signal

off (phase sequence) interval when not operating and signals are not displayed (for part-time traffic signals)

pedestrian clearance the interval period following the termination of the pedestrian walk interval to allow pedestrians to complete their crossing to the nearest kerb or pedestrian refuge. It consists of the pedestrian clearance 1 interval and the pedestrian clearance 2 interval.

QCT queue clearance time; the elapsed time from the commencement of the clearance phase that it takes for a vehicle that may be queued across the level crossing to completely clear the level crossing

red interval when the related movement is stopped

RIU railway interface unit

SCATS Sydney coordinated adaptive traffic system

signal display an aspect illuminated to direct traffic

signal group set of traffic signals with common electrical switching such that the signal display of each traffic signal is identical

SPOP special purpose output

TD train demand indication from the railway system to the TSC indicating a train is approaching

TDRT train demand response time; advance warning time required by the TSC of an approaching train prior to the level crossing commencing to operate

TfNSW Transport for NSW

TLR traffic light response; indication from the TSC to the railway system indicating that the traffic signal controller is ready for the level crossing to commence operating for the passage of a train

traffic signal

- an assembly including aspects, visors and target board to control user movements
- an intersection or crossing controlled by traffic signals

train mode the operating condition that a TSC is in when a train demand or crossing operating indication is received

TSC traffic signal controller

VSS video surveillance system

walk (pedestrian interval) the interval provided to allow pedestrians to start their crossing; it consists of walk 1 and walk 2

XE level crossing operation; indication from the railway system to the TSC indicating the level crossing flashing lights are operating

XSF extra special facility

yellow interval in the clearance part of a phase; used to stop one or more movements before the next phase starts

5 Level crossing interface

5.1 General

Section 5 sets out requirements for coordination and configuration of traffic signal intersections where they are interfaced with active level crossings. An example of such an intersection is shown in Figure 1.

Technical design requirements and guidance for designing such intersections, including geometry and hardware, are provided in TS 02670.2.

Figure 1 – Signalised intersection with level crossing at Faulconbridge, NSW

5.2 Coordination

Traffic signals can be coordinated with an active level crossing to enable queue management and consistent driver messaging. The railway authority should establish a train detection system, to communicate to the TSC when a train is on approach to and then clear of the crossing.

Train detection is communicated to the TSC by an electrical interface cable connected to a RIU incorporated into the TSC. Interface details and requirements are provided in TS 05317. The

RIU is described in TS 06328.1, and the procedure for installing the RIU in the TSC is provided in TS 06328.2.

The need for such a system shall be determined in consultation with the relevant railway authority during the design process (refer to TS 02670.1).

5.3 Operation principles

Section 5.3 covers the use and principles of operation where a coordinated interface between the level crossing and the TSC is installed. The requirements are aimed at consistency, irrespective of the railway authority involved.

For railway system operating principles, refer to TS 05333.18.

5.3.1 General

Coordination between the level crossing and the intersection depends on:

- vehicle types using the intersection and level crossing
- time taken for vehicles to traverse the level crossing and intersection
- distance between the level crossing and the intersection
- drivers' line of sight and resultant perception of railway and vehicle warning systems (for example signs, lights or bells)
- configuration and layout of the site
- time between train detection and level crossing operating.

Coordination of the level crossing and traffic signal operation aims to minimise the following queuing incidents:

- Traffic queued from the intersection stop line back towards or through the level crossing (caused by a red signal display, congestion, pedestrian movement or short stacking). This may be addressed with:
    - traffic signal control on the approach to the level crossing – prevents queues forming across the level crossing
    - a vehicle detector to identify queue formation and respond, when possible, with a green signal – reduces queue length
    - a clearance phase which gives a green signal to queued vehicles ahead of the train coming – discharges any formed queue before the train arrives.

- Traffic queued from the level crossing stop line back towards or through the intersection. This may be addressed by:
  - ensuring vehicles (particularly long vehicles) have sufficient time to clear the intersection and the level crossing before the level crossing starts operating
  - preventing vehicles from entering the roadway between the intersection and level crossing when the level crossing is operating.

When coordinated operation of the level crossing and traffic signals is adopted it should align with the following principles:

- control any movements towards the level crossing with traffic signals
- initiate a queue-clearing sequence at a set time before the train arrives at the level crossing.

If queues are likely to develop on a departure side of the level crossing, queue detectors (refer to TS 02670.2) can be installed and used to initiate a special phase sequence. This will inhibit movements feeding the queue or run phases that clear the queue.

5.3.2 Description

To provide coordination, the TSC shall be provided an advance warning that a train is approaching. To achieve this advance warning, train detection shall be provided by the railway system to enable certain actions by the TSC.

On receipt of an advance warning the TSC shall commence either or both the following actions:

- terminate certain phases or signal groups (preventing traffic from approaching the level crossing)
- run a clearance phase (see Section 5.3.3.1).

When the level crossing is operating, phases allowing movements which do not conflict with the level crossing should continue to cycle.

The railway system should include the advance warning indications shown in Figure 2, as outputs to the TSC:

- TD, starting when a train is detected approaching the level crossing and ending once the train has cleared the level crossing and the boom barriers start to rise
- level crossing operating (XE), for the duration the flashing warning lights are active.

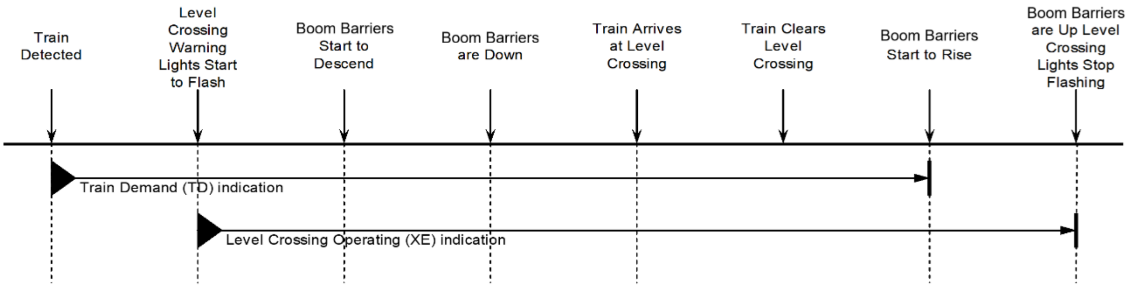

Figure 2 – Train demand and level crossing operating (XE) indication periods

To ensure that the TSC can respond to the TD and put the traffic signals in a state which allows for level crossing operation, the railway system shall provide the TD before the train arrives at the level crossing, as shown in Figure 3. This is the TDRT, and its calculation is described in Section 5.4.9.4.

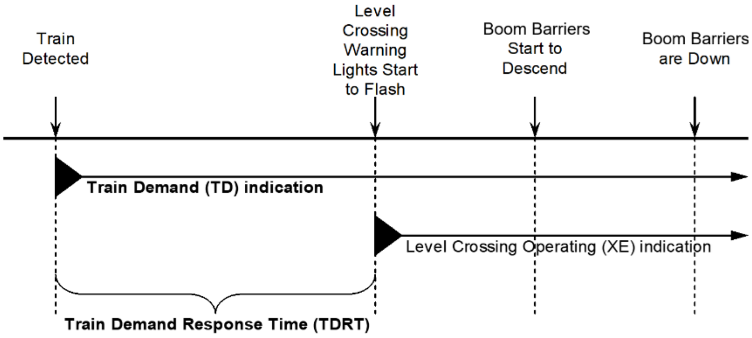

Figure 3 – Train demand, level crossing operating (XE) and train demand response time

The TSC can send a TLR indication to the railway system when it is ready for the level crossing to commence operation. The TLR is in reply to the TD and XE indications, and enables the level crossing to begin operating without having to wait for the TDRT to elapse.

The time period between TLR and XE commencing, as shown in Figure 4, varies from between 100 ms to 30 s depending on the following conditions:

- the best-case or worst-case time taken to terminate the running phase and transition to ready for level crossing operation
- the railway system response time after the TLR is provided
- ability of the train, and level crossing operation, to take advantage of the TLR.

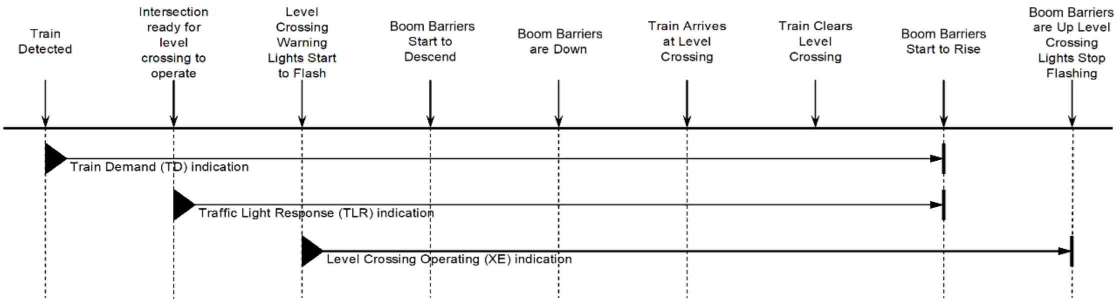

Figure 4 – Train demand, level crossing operating (XE) and traffic light response indication periods

The intersection design should incorporate the following two sets of phasing operation:

- normal phase set – during the absence of TD
- train phase set – during the presence of TD.

Further details of phasing are included in Section 5.4.1.

5.3.3 Phase transition

If the operation is to transition to a train phase set or clearance phase when a TD is received, the TSC should be configured so the running phase terminates as early as possible, provided the following safety times are met:

- a minimum vehicle green of 5 s
- pedestrian clearance times as set
- yellow times as set
- all-red times as set.

If there are traffic signals on the approach to the level crossing, they should provide a red signal display during the presence of XE.

Red signal displays should be shown to movements approaching the level crossing as soon as possible after the receipt of a TD and while TD is still present.

The controller can transition to the normal phase set after the TD has terminated and resume the normal phase set after the XE has ceased.

5.3.3.1 Clearance phase

A clearance phase allows vehicles trapped on the level crossing to clear it before or shortly after the warning lights start flashing, and before any boom barrier starts lowering. A clearance phase may be included in a design, whether there is a train phase set or not.

During the clearance phase, green signal displays shall be shown to vehicles that have already passed over the level crossing, and red signal displays to vehicles on approach to the level crossing.

As shown in Figure 5, during the clearance phase, vehicles queued between the railway line and the intersection can move clear of the crossing before it starts operating. The queue clearance time begins at the start of the clearance phase and extends until the last queued vehicle clears the level crossing. For calculation of QCT see Section 5.4.9.2.

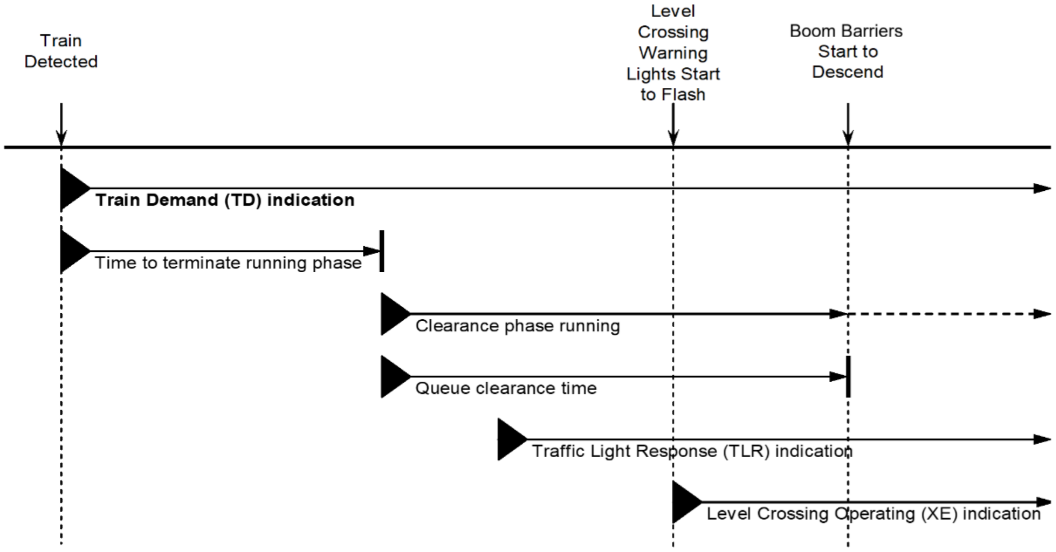

Figure 5 – Phase sequence with clearance phase

There can be a variable delay of a few seconds or more depending on the time taken to terminate the signal groups in the running phase, transition to the clearance phase and stay in that phase for the QCT. The maximum TDRT is the worst-case time for the traffic signal controller to terminate any running phase, move to the clearance phase, and stay in that phase for the QCT.

To minimise TDRT the signal operation may start the clearance phase during a phase transition.

The clearance phase can be extended beyond the minimum QCT to clear all vehicles (for example, long vehicles) queued between the level crossing and the intersection stop line.

5.3.3.2 Without clearance phase

When a clearance phase doesn't exist (for example, where the railway line adjoins or crosses the intersection), the phasing sequence shall ensure vehicles cannot become trapped within the level crossing.

A variable delay of a few seconds or more can occur depending on the time taken to terminate the signal groups in the running phase and transition to a selected phase in the train phase set.

The TDRT is the worst-case time for the TSC to terminate any running phase and move to the selected phase in the train phase set, as shown in Figure 6.

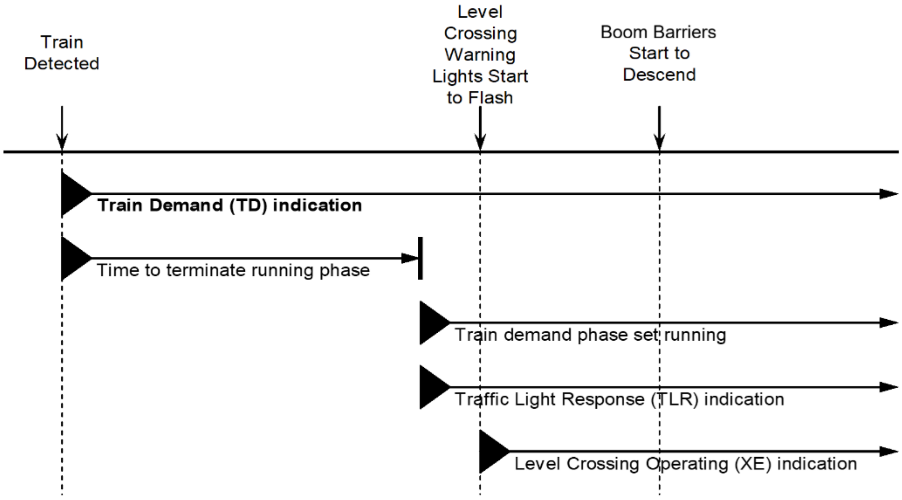

Figure 6 – Phase sequence without clearance phase

The train phase set should begin with a phase which is most similar to the one that was running when the TD was received. If no similar phase exists, the one most likely to have been demanded next should be selected as the initial phase.

To minimise TDRT the signal operation may start the initial phase during a phase transition.

5.3.3.3 Conflicting movements

Once a TD is received, vehicle or pedestrian movements that conflict with the clearance phase or initial phase shall not be introduced until after that phase has ended.

If a vehicle signal group that conflicts with the clearance phase or initial phase is already displaying green when a TD is received, the green signal display shall be terminated after at least 5 s has elapsed.

If a pedestrian signal group that conflicts with the clearance phase or initial phase is already displaying green when a TD is received, the green signal display shall be terminated immediately (whether the walk time has elapsed or not) and the pedestrian clearance started. This may not be possible at MFCs used by school children, slow-walkers, or people with visual impairments.

If a TD is received and there is a pedestrian demand for a conflicting movement, then the pedestrian demand may be suppressed until a phase without conflict can be provided.

Overlap of pedestrian walk or clearance intervals may be implemented but can affect efficiency and responsiveness to TDs.

5.3.4 Traffic light response

When the traffic signals are ready for the level crossing to begin operations, a TLR indication can be sent to the railway system. The TLR remains active until the TD ceases.

The TLR shall be provided and the controller configured to recognise TD and XE indications when one of the following two conditions are present, whichever occurs first:

- the train phase set commences operating
- the clearance phase has been running for a time equal to the QCT minus the gate delay (see Section 5.4.9.3).

5.3.5 Successive operation

Successive operation can be provided for instances where a second train approaches the level crossing while the first train is still passing through it. The TD for the second demand shall be processed with one of the following methods, depending on when it is received:

- Second TD while the first TD is still active. In this case the demand is continuous, the train phase set continues until all TDs have ceased and transitions to the normal phase set when the level crossing ceases operating.
- Second TD shortly after the level crossing has ceased operating. In this case the demand is treated as a new and separate demand.
- Second TD after the first TD has ceased, the TLR is terminated, and the railway system may have started to raise the boom barriers. In this case the demand is treated as a new and separate demand.

5.3.6 Fault monitoring

The TSC is connected to SCATS to enable the site to be monitored for railway system faults and alarms.

When the TSC detects a fault with the TD, XE or TLR circuits, it can be programmed to run a specific routine and send notification to SCATS.

For further details on faults see Section 5.4.8.

5.4 Configuration principles

Section 5.4 applies when the rail system and TSC are coordinated. It describes configuration application of the controller personality, interface status monitoring, and TSC operation with the railway system. Coordination between the TSC and railway systems depends on the specific configuration of the site, and type and extent of vehicles using it. Examples are provided to illustrate some of the design principles.

5.4.1 Phasing

The design layout (and controller personality) should incorporate the following two sets of phasing operation:

- normal phase set the controller cycles in the absence of a TD
- train phase set in the presence of a TD consisting of one or more phases which omit movements that proceed towards the level crossing.

All movements towards the level crossing should be controlled and not include right or left turn filter movements (refer to TS 02670.2).

Red signal displays should be shown to all movements approaching the level crossing soon after the receipt of a TD and remain while TD is present.

A clearance phase (see Section 5.3.3.1) shall not terminate before the level crossing boom barriers start to lower.

After a train has cleared the level crossing and it ceases operating, a transition phase may be run before reverting to the normal phase set using special facility signals. An example of this phasing in shown in Appendix A.3.1.

5.4.1.1 Start-up

A TD can either be already present or arrive during the TSC's start-up sequence. In each case the initial phase should be a specific phase of the train phase set; or if already operating another phase, change to the train phase set at the earliest phase termination.

5.4.1.2 Phase time settings

The inclusion of a train phase set means normal phase transition timings and minimum green intervals may need adjusting. Standard phase time settings are detailed in TS 05493.

If the phase following a TD permits traffic queued at the level crossing to proceed through the intersection, then a longer minimum green may be applied to allow the queued vehicles time to travel past the intersection stop line before the phase terminates. See Appendix A.3.2 for an example.

If applying time setting changes, the following should be taken into account:

- clearance phase minimum – a much shorter interval than originally set may result in a frequent 'crossing operating early' alarm
- clearance phase maximum – a much longer interval than originally set may delay drivers. It is timed from the start of a TD to the end of the worst-case (longest) phase interval, before the level crossing boom barriers begin to lower.

5.4.1.3 Diversion

Diversion allows a TSC to respond quickly to a TD, by allowing a late change to the next phase selection during phase intergreen (see Appendix A.1.4).

Diversion should be provided but does place restrictions on any overlap signals displayed to drivers, and therefore affects the overall efficiency of the intersection.

Where diversion during intergreen is not provided, the controller personality should be configured to prevent the introduction of any new signal groups when the next phase starts. This will prevent minimum timers being started and allow the phase to terminate and transition to the next appropriate phase.

5.4.2 Train mode

Train mode is the TSC response to the indicators provided by the railway system. TD and XE each have two indicators, one normally open and one normally closed (refer to TS 05333.18). The TSC will enter train mode under any of the following conditions:

- a valid, fault-free, TD is indicated
- only one of the TD indicators changes state
- a valid, fault-free, XE is indicated
- only one of the XE indicators changes state.

Note: Fault conditions are explained in Section 5.4.8.

If the TSC is in train mode for an extended period (as determined in consultation with TfNSW Network Operations) and either of the TD or XE indication is in an alarm state, then the TSC will revert to flashing yellow operation. Leaving train mode will reset the measurement of the period. Reversion from flashing yellow to normal operation may only occur if train mode is removed or until on-site intervention.

The level crossing may be operated manually by use of a switch rather than a train and the railway system. The level crossing is considered to be under manual control if the TD and XE indication turn on, in any order, within a period set by in the controller personality (commonly one second).

When the TSC is ready for the train, a TLR (see Section 5.3.4) is provided to the railway system to enable the level crossing to operate earlier than the worst-case time. TfNSW Configuration Management shall specify which controller SPOPs are to be used for the TLR indication with respect to any other SPOPs being used at the site. An example is provided in Appendix A.3.3.

5.4.3 Traffic signals at level crossing approach

When signal faces are installed adjacent to or near a level crossing, and drivers can also see the RX-5 assembly, the traffic signal faces should only include yellow and red aspects (refer to AS 1742.7 for details on RX-5 assembly). This ensures that a green traffic signal and flashing red warning signals cannot be displayed simultaneously to vehicles arriving at the level crossing.

Where traffic signals are on the far side of a level crossing, green signal displays should not be visible across the level crossing at the same time as the red flashing signal of the RX-5 assembly.

If traffic signals are installed on the approach to the level crossing, they should operate in either of the following sequences:

- The signal display is normally off and changes to:
  - yellow when a TD is received
  - from yellow to red after 5 s
  - from red to off when the TD is cleared.

  This type of operation may be used when it is unlikely that vehicles become trapped on the level crossing.
- The signal display is normally red and changes to off when there is no TD, and there is a demand from a detector on the same approach and the downstream signal display is green. The display remains off for at least 5 s and changes to yellow if a TD is received or if the running phase is ready to terminate. The signal display changes from yellow to red after 5 s.

When the red signal display changes to off, the downstream traffic signal shall not display yellow until all vehicles have cleared the downstream stop line (and its detector's gap timer has expired) to keep the level crossing clear of queued vehicles. This type of operation may be used when long vehicles cannot be accommodated between the intersection stop line and the level crossing, or when the railway system provides less than the minimum TDRT (see Section 5.4.9.4).

5.4.4 Turning movements

Three-aspect arrow traffic signals should be provided for all turning movements proceeding from the intersection to the level crossing to ensure those movements are fully controlled.

Phases which include turning movements towards the level crossing shall not be introduced until the train has cleared the level crossing. Storage for queued turning vehicles while the level crossing is operating should be provided.

5.4.5 Pedestrian movements

A running pedestrian movement can result in a prolonged TDRT. For example, if a pedestrian movement conflicts with a movement that runs during the clearance phase, and the MFC is long because of the roadway width. Shortening the MFC using kerb blisters or adopting two-stage operation may reduce the walk time and therefore the TDRT.

5.4.6 Simulation

During development of the concept design (refer to TS 02670.2), the proposed intersection and level crossing operation should be modelled with typical train frequencies and road traffic (based on counts or survey). The modelling should aim to confirm the operation is safe and efficient and extend to simulating times of higher than typical train frequency and traffic demand (to ensure that queues across the railway tracks and signalised intersection are within capacity).

5.4.7 Operational monitoring

The TSC shall be connected to SCATS to provide remote monitoring of site operation. The controller personality should be configured to provide indications to SCATS to signify the operational mode of the traffic signal controller. This allows the state of the intersection to be remotely monitored by TfNSW Network Operations. The following list are examples of what can be monitored:

- state of the TD indication
- state of the XE indication
- state of the TLR indication
- if the level crossing is manually operated
- if the controller is in train mode.

Appendix A.3.4 provides an example of the monitoring indicators.

The use of SPOPs in place of external detector inputs for the monitoring of the railway system outputs is not recommended. Detector status is automatically provided to SCATS for monitoring purposes.

5.4.7.1 Video monitoring

A VSS should be installed at level crossing sites and connected to a remote monitoring facility which is triggered when a TD is received. This provides a facility to record driver behaviour on and around the level crossing when a train is approaching. VSS requirements at traffic signals are contained in TS 02670.2.

Where a VSS is provided, the controller personality should be set-up to provide a SPOP to control the recording process. The SPOP should be on from the time that the TD is received until after the level crossing ceases to operate (that is, when XE is turned off). A time setting should be used to extend the recording process beyond XE being turned off. The time setting should be greater than 12 s.

5.4.8 Faults

When the controller detects a fault with the TD, XE or TLR indications a high-priority alarm (for example, SF alarm) shall be generated and communicated through SCATS.

Monitoring of each of the two TD and XE indication circuits for faults is shown in Table 1. The two indications are used for safety redundancy, therefore where only one of those circuit states changes a fault is detected, and a TD still recognised.

Table 1 – TD and XE circuit fault monitoring

Circuit 1	Circuit 2	Status
Closed	Open	not active (normal)
Open	Closed	active (normal)
Open	Open	active with fault
Closed	Closed	active with fault

5.4.8.1 Monitoring and management

A TSC interfaced with a level crossing shall be connected to SCATS to provide remote fault monitoring and alarm notification.

Both TfNSW and the railway authority should nominate a contact person for each interfaced level crossing site and establish an agreed protocol for reporting issues with the operation of either system.

The design documentation should specify which of the following modes of operation are configured if the controller detects a fault in the TD or XE indications:

- after any clearance phase has run, the controller remains in the train phase set until the fault is cleared
- the controller reverts to normal phase set signal operation (relying on driver observance of road rules to keep the intersection and crossing clear)
- the controller switches all signals to flashing yellow.

5.4.8.2 Alarms

To enable diagnosis of faults, the TSC shall provide alarm indications to SCATS when:

- the site is in flashing yellow (fault fall-back mode) due to the train mode operating for an extended period (see Section 5.4.2), and TD or XE indication has an alarm state
- TD inputs are not in agreement
- XE inputs are not in agreement
- TLR feedback indication is present while TLR is not indicated
- XE indication changes state from off to on while TD is not indicated
- XE indication is present for longer than a defined period after TD is removed
- TD is removed while XE is applied
- XE indication changes state from on to off while TD is present – while the level crossing is not under manual control and the TD is a repeat demand
- XE indication changes state from off to on earlier than expected, before the TLR is indicated and:
  - the level crossing is not under manual control
  - the controller has not started up in the clearance phase
  - there is more than two seconds to go until the TLR is indicated
- XE indication is on approximately two seconds before the TLR is due to be indicated, and:
  - the level crossing is not under manual control
  - the controller has not started up in the clearance phase.

  Note: There is a difference between the last two conditions. The first detects a change in state from off to on. XE should never turn on before the TLR. The second detects the on state of XE relative to when the TLR should turn on. XE can be on before the TLR during a train phase if there is a repeat TD.

Other fault conditions may be reported, as determined by TfNSW.

Primary alarms should be assigned to special facility inputs of the TSC. Secondary indications using MSS bits can be provided where special facility inputs are exhausted, to aid in remote diagnosis. All alarms should be set to ensure they are not cleared when the circumstances or conditions that triggered the alarms have returned to normal. A facility for the remote clearing of alarms using the SCATS interface should be given. Provision should be made for locally clearing the alarms.

Alarms should not be cleared unless the reason for their existence is understood, rectified, and the situation deemed safe.

For examples of alarm definition and operation, see Appendix A.3.5.

5.4.9 Time settings

Section 5.4.9 provides specific guidance for determining the following time settings for the TSC and RIU to work safely and efficiently with the level crossing:

- queue clearance time
- train demand response time
- gate delay.

5.4.9.1 Time to transition

Whilst time to transition is not a controller time setting, it is used in determining other time and phase settings (see also Section 5.3.3).

The time to transition from the running phase to the train phase set or clearance phase depends on the running phase and movements. For examples of how to calculate the time to transition, see Appendix A.1. In practice, it lies somewhere between the following best-cases and worst-cases:

- The best-case (shortest delay) is where the running phase has already terminated and the transition to the next phase is immediate, including any remaining safety times.
- The worst-case (longest delay) is where the running phase has only just been initiated and cannot be terminated, and transition to the next phase commence until the safety times are reached. Typically, the longest delay is when terminating a pedestrian movement.

The time to transition is the greater of the following resultant times:

- The longest pedestrian clearance. This assumes that the TD arrives at the start of the pedestrian clearance interval, either by normal progression or immediate termination of the walk interval. In addition, the pedestrian clearance ends at the end of all-red.
- The sum of minimum green interval and intergreen times (see Section 5.4.1.2).

5.4.9.2 Queue clearance time determination

QCT enables any queued traffic that may have formed across the level crossing to move clear before the level crossing begins operating. Therefore, QCT shall be long enough to clear the queue that may have formed along path A in Figure 7. The determination of the QCT should also consider the types of vehicles using the level crossing, for example passenger vehicles, heavy vehicles (including service, single unit, B doubles).

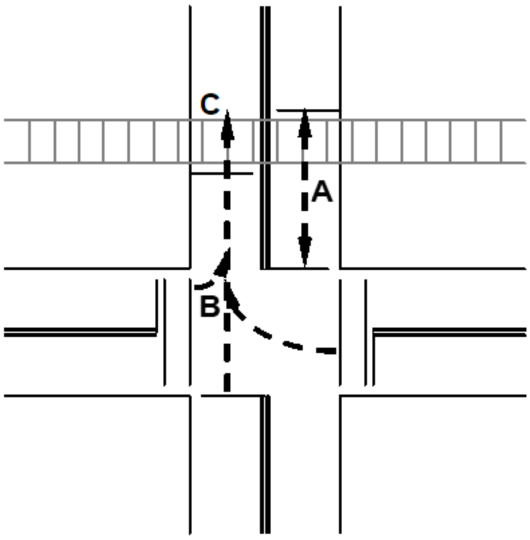

Figure 7 – Example situation for time settings

QCT length shall account for the worst-case scenario, where the slowest or longest vehicle is stopped at point C in Figure 7, (that is, just on the level crossing), to ensure that the slow moving or slow accelerating vehicle is clear of the level crossing when the boom barriers begin to lower.

The QCT shall be determined in consultation with TfNSW Network Operations.

QCT may be determined by either an empirical or calculation method. Each method should be used to confirm that the chosen value is appropriate.

For each method, the clearance position shall be determined, that is, the place at which the last vehicle in the queue obstructing the level crossing has been cleared. This shall correspond with (in order of preference) when the vehicle either:

- clears (has passed) the intersection stop line
- reaches the intersection stop line
- clears (has passed) the level crossing.

5.4.9.2.1 Empirical method

Queue dynamics can be measured at site to determine the maximum length of time that it takes for all vehicles to be clear of the level crossing once the clearance phase has commenced. This measurement should look at all times of the day and week to ensure that unusual patterns are identified, and timed to find the maximum time to clear the level crossing of queued vehicles.

The queue dynamics should be reviewed periodically, to account for the development and change in use of the road and area, and hence change in vehicles using the intersection and level crossing.

5.4.9.2.2 Calculation method

The calculation method is based on the following principles:

- a stationary driver takes a specific time to respond (initial movement) to a change in the traffic signals. This time is subject to the following conditions:
    - the driver's reactions
    - the gradient of the road at the vehicle's starting point
    - the responsiveness of the vehicle, in relation to variation in its drivetrain, mass and power
- a driver takes a specific time to move from the start position to the clearance point which is subject the following conditions:
    - the vehicle's distance from the start position to the clearance point
    - the vehicle's average acceleration rate, in relation to the following variables:
        - the road alignment (vertical and horizontal) between the vehicle's start position and the clearance point
        - the road pavement type
        - the vehicle's direction of travel through the intersection (be it a through or turning movement)
        - the driver's desire to accelerate and travel at the speed limit
        - the clear distance in front of the vehicle.
- the number and type of vehicles from the intersection stop line to and including the vehicle which is obstructing the level crossing.

A detailed example is shown in Appendix A.2.

A problem with the calculation method is that it can be conservative in the chosen values for vehicle acceleration, driver reaction, vehicle length and vehicle separation, and result in an inefficient QCT.

5.4.9.3 Gate delay

The level crossing gate delay is the time between the warning lights beginning to flash and the boom barrier starting to lower. The gate delay allows for vehicles to clear the level crossing. This is a parameter that is set in the railway system and is expressed as a range because of the variation in the mechanical tolerances of the boom barrier.

Level crossings typically have a gate delay of between 10 s to 12 s. Where long or slow-moving vehicles use the level crossing, a longer gate delay may be used to allow that vehicle to be clear by the time the boom barrier lowers. The typical gate delay for the following four vehicle categories reflect the vehicle's speed and acceleration.

- no multi-combination vehicles – 12 s
- B-doubles – 12 s
- double road train – 16 s
- triple road train – 21 s

The gate delay shall be determined in consultation with the railway authority.

5.4.9.4 Train demand response time determination

The TDRT influences the correct operation of the level crossing interface. Its determination is derived from the following inputs:

- the time to transition to the train phase set or clearance phase (see Section 5.4.9.1)
- the QCT (see Section 5.4.9.2)
- the gate delay (see Section 5.4.9.3)
- the time for a vehicle to clear the intersection conflict zone and pass the level crossing before the warning lights start to flash (shown in Figure 7 as paths labelled B). This should be the worst-case time, which is typically for a filter right turn movement. The time also depends on the vehicle type.

The TDRT shall be determined in consultation with TfNSW Network Operations and advised to the rail authority. The rail authority uses this time to determine how far before the level crossing it needs to position train detection devices.

TDRT shall be the greater of the following resultant times:

- for a stationary vehicle to commence a filter right turn, clear the intersection conflict zone and pass the warning lights
- the sum of time to transition and QCT less gate delay.

5.4.10 Advisory signs

If the level crossing is likely to operate for long periods (for example, due to shunting of trains through the level crossing), variable message signs may be installed. These can, for example, indicate the signals and level crossing are operating correctly. This may also apply if the train phase is extended by successive TDs.

The message text shown on the sign shall be determined in consultation with TfNSW.

Appendix A Level crossing interface examples

A.1 Train demand and time to transition

Appendix A.1 provides several timing examples for determining the time to transition to the clearance phase or the train phase set.

For worst-case calculation purposes it is assumed that the TD is received at the start of the phase interval, not part-way through.

The ECG interval is used to allow some signal groups to be terminated earlier than others and therefore extends the overall intergreen time, as explained in TS 02670.2. ECG is not used at all intersections or for all phases at an intersection. When ECG is used, its length can be reduced to zero for particular phase transitions.

Phase intervals are shown in Figure 8, and detailed in TS 05493.

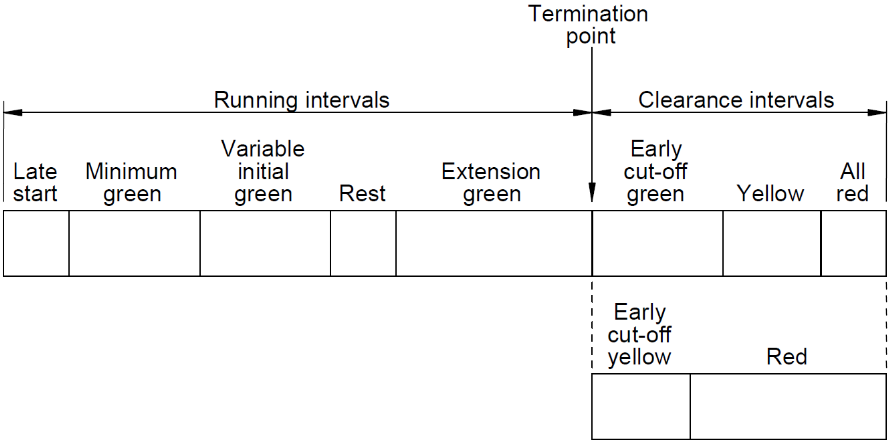

Figure 8 – Phase intervals

A.1.1 Train demand during late start

If a TD is received during a late start of any phase, the phase cannot be terminated immediately. The delay before the clearance phase or train phase set can be introduced, is equal to the length of all the following phase intervals:

- late start (where used)
- minimum green
- ECG (where used)
- yellow
- all-red.

The phase intervals variable initial green, rest and extension green have their times set to 0 s.

A.1.2 Train demand during minimum green

If a TD is received during minimum green of any phase, the phase cannot be terminated immediately. The delay before the clearance phase or train phase set can be introduced, is equal to the length of all the following phase intervals:

- minimum green
- ECG (where used)
- yellow
- all-red.

The phase intervals variable initial green, rest and extension green have their times set to 0 s.

A.1.3 Train demand after minimum green

If a TD is received during variable initial green, rest or extension of any phase, the phase can be terminated immediately. The delay before the clearance phase or train phase set can be introduced, is equal to the length of all the following phase intervals:

- ECG (where used)
- yellow
- all-red.

The phase intervals variable initial green, rest and extension green are either already complete, terminated immediately or have their times set to 0 s.

A.1.4 Train demand during intergreen

During normal TSC operation, it is common to change the next phase at the termination point of the running phase.

To improve the responsiveness of the TSC interface with the level crossing, the controller personality can be configured so it diverts from the next phase to the clearance phase, or the train phase set, while the running phase is in the intergreen. To allow for such diversions, the TSC also needs to be configured to identify and respond to any overlap signal groups.

A.1.4.1 No diversion

Where diversion is not used, the controller personality should be configured to prevent the introduction of any new signal groups when the next phase starts. This will prevent minimum timers being started and thus allow the phase to terminate quicker and transition to the clearance phase.

Without diversion, the delay before the clearance phase or the train phase set can be run is equal to the length of all the following phase intervals:

- running phase:
  - ECG (where used)
  - yellow
  - all-red
- next phase:
  - late start (where used)
  - minimum green
  - ECG (where used)
  - yellow
  - all-red.

A.1.4.2 Diversion permitted

Where diversion is used, the delay before the clearance phase or the train phase set can be run, depends on when the TD is received and the point at which the diversion takes place. The delay could be as short as 100 ms, or as long as the length of all the clearance intervals.

A.1.5 Train demand during pedestrian walk

Wherever the running phase is in its cycle with an active pedestrian movement, the pedestrian clearance intervals complete before the running phase can end.

Wherever in the cycle a TD is received, the pedestrian walk should be terminated immediately (which is not always possible depending on intersection geometry and pedestrian type) and the clearance intervals fully completed. The minimum delay before the clearance phase or the train set phase can be run, is equal to the length of both pedestrian clearance periods. This delay can be increased by the length of the pedestrian walk if termination is not possible.

A.2 Queue clearance time

Appendix A.2 provides site-specific examples of QCT calculations to illustrate the concept of a level crossing interface in operating conditions. The methods of determining QCT are described in Section 5.4.9.2.

The calculated values depend on the site conditions. Additional factors include road gradients and alignments.

The following methodology describes a simplified model of queue dissipation. Drawing notes are included to indicate where this method could affect results and how the use of conservative data compensates for this.

The intersection layout for this QCT example is shown in Figure 9, where the distance between the intersection stop line and the level crossing stop line (labelled 'A') is 50 m. This intersection is regularly used by cars and heavy vehicles (including B-doubles).

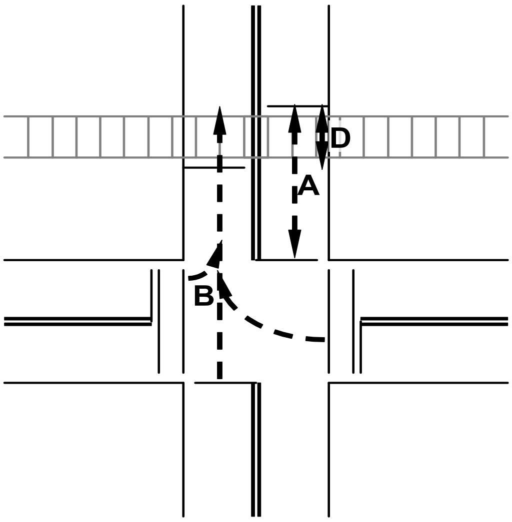

Figure 9 – Example intersection for QCT calculation

The following assumptions are made for this example:

- posted speed limit of the road is 60 km/h
- vehicle lengths correspond to the design vehicles listed in Austroads *Guide to Road Design Part 4: Intersections and Crossings – General* and TS 02642
- passenger vehicle driver reaction time is 1 s (this is the time taken between the signal display changing and the initial driver movement)
- heavy vehicle driver reaction time is 3.25 s, accounting for drivetrain losses, mass, and power
- passenger vehicle average acceleration rate is 1.7 m/s^2
- B-double average acceleration rate is 0.4 m/s^2
- stopped vehicle separation is 1.5 m. The actual distance can range from as little as 0.5 m to more than 2.5 m depending on individual driver behaviour
- queue dissipation time of passenger vehicles is 2 s per unit
- level crossing width is 10 m, measured from the level crossing stop line to the corresponding boom barrier (labelled D in Figure 9). This will vary with the number of railway tracks and element clearances.

The composition of the queue may also affect the way it adapts to the level crossing.

A.2.1 Scenarios

The three scenarios provided in Appendices A.2.2, A.2.3 and A.2.4 demonstrate a range of QCTs determined for a given intersection.

In all the scenarios, it is assumed that the driver of the last vehicle continues onto the level crossing without ensuring they can safely clear it. It is also assumed that any following vehicles (shown in grey in Figure 10, and) stop at the level crossing and do not attempt to cross it.

A summary of the scenario results is shown in Table 2.

Table 2 – QCT scenarios

Case	Description	Scenario 1	Scenario 2	Scenario 3
A	Time for the last vehicle to pass the intersection stop line	19 s	29 s	25.5 s
B	Time for the last vehicle to reach the intersection stop line	18.5 s	25 s	20 s
C	Time for the last vehicle to clear the level crossing	12 s	22.5 s	16 s

Note: All calculated values have been rounded up to the nearest half second.

A.2.2 Scenario 1

In this scenario, the last vehicle obstructing the level crossing is a passenger vehicle, as shown in Figure 10

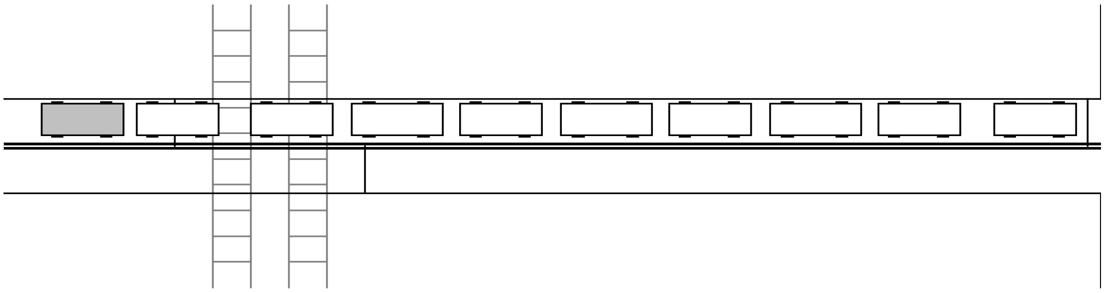

Figure 10 – Scenario 1 passenger vehicles on level crossing

A.2.2.1 Case A

If there are only passenger vehicles in the queue, then the distance to the back of the car on the crossing from the intersection stop line can be calculated as:

Distance to back of car = (number of vehicles × vehicle length) + (number of separations × separation length).

For example, number of vehicles is 8, vehicle length is 4.5 m, number of separations is 7, the separation length is 1.5 m.

The distance to the back of the car on the crossing is:

(8 x 4.5) + (7 x 1.5) = 46.5 m.

In this case, the eighth vehicle is on the level crossing.

For worst-case scenarios, it should be assumed that the vehicle following may also have encroached past the level crossing stop line onto the level crossing.

The back of this ninth vehicle from the intersection stop line is:

(9 x 4.5) + (8 x 1.5) = 52.5 m.

The QCT for the nine cars is calculated as:

QCT = number of cars × queue dissipation time + reaction time of first vehicle.

For example, number of cars is 9, queue dissipation time is 2 s, the reaction time for the first vehicle is 1. The QCT is:

(9 x 2) + 1 = 19 s.

A.2.2.2 Case B

If it is determined that the last vehicle does not have to clear the intersection stop line, then the queue dissipation assumption is no longer valid.

If the car on the level crossing only has to reach the intersection stop line, then the time is slightly less, about 18.5 s.

This is based on the vehicle already moving so it reaches the intersection stop line sooner.

A.2.2.3 Case C

If the last vehicle does not have to clear the intersection stop line, the queue dissipation assumption is no longer valid.

If the car on the level crossing only has to clear the level crossing, the method provided in ‘A Behavioural Car-following Model for Computer Simulation’ is used. This results in the following value, which should be confirmed by field-testing: 12 s.

A.2.3 Scenario 2

In this scenario the last vehicle obstructing the level crossing is a B-double, at its front, as shown in Figure 11. The last, eighth car, on the level crossing is followed by a B-double.

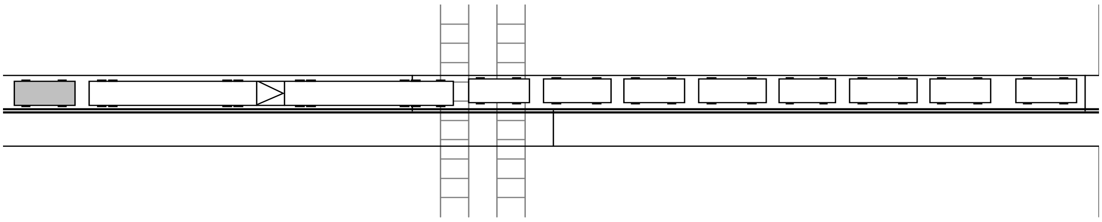

Figure 11 – Scenario 2 B-double entering level crossing

A.2.3.1 Case A

The back of the eighth car from the intersection stop line will be:

(8 x 4.5) + (7 x 1.5) = 46.5 m.

This puts the eighth car on the level crossing. For worst-case scenarios it should be assumed that the following B-double may also have encroached past the level crossing stop line and be on the level crossing. In this case, the distance from the back of the B-double to the intersection stop line will be:

(8 x 4.5) + (1 x 26) + (8 x 1.5) = 74 m.

Using the queue dissipation assumption would provide the same result ,19 s, as Scenario 1 (see Appendix A.2.2.1). However, the inclusion of a non-car invalidates the assumption. A realistic queue dissipation time can instead be calculated using the method provided in ‘A Behavioural Car-following Model for Computer Simulation’, resulting in a QCT of 29 s.

A.2.3.2 Case B

Where the B-double only has to reach the intersection stop line, then the back of the B-double from the intersection stop line will be 26 m.

Therefore, the travelled distance is calculated as follows:

Travelled distance = (back of B-double from the intersection stop line) − (length of B-double)

For example, back of B-double from the intersection stop line is 74 m and length of B-double is 26 m, the travel distance is:

74 − 26 = 48 m.

The method provided in ‘A Behavioural Car-following Model for Computer Simulation’ produces a QCT of 25 s.

A.2.3.3 Case C

Where the B-double only has to clear the level crossing then the back of the B-double from the intersection stop line will be calculated as follows:

(distance between stop lines) − (width of level crossing).

For example, distance between stop lines is 50 m and the width of the level crossing is 10 m, the back of the B-double from the intersection stop line is:

50 – 10 = 40 m.

Therefore, the travelled distance is calculated as follows:

Travelled distance = (back of B-double from the intersection stop line, entering level crossing) – (back of B-double from the intersection stop line, clear of level crossing).

For example, back of B-double from the intersection stop line, entering level crossing is 74 m and back of B double from the intersection stop line, clear of level crossing is 40 m, the travelled distance is:

74 – 40 = 34 m.

The method provided in ‘A Behavioural Car-following Model for Computer Simulation’ produces a QCT of 22.5 s.

A.2.4 Scenario 3

In this scenario the last vehicle obstructing the level crossing is a B-double at its rear, as shown in Figure 12.

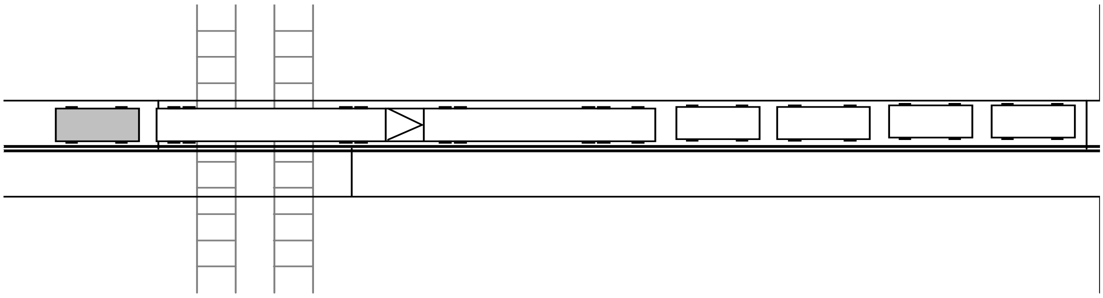

Figure 12 – Scenario 3: B-double on level crossing

A.2.4.1 Case A

In this scenario the B-double is preceded by four cars. The distance to the back of the fourth car from the intersection stop line will be:

(4 x 4.5) + (3 x 1.5) = 22.5 m.

The distance to the back of the B-double from the intersection stop line will be:

(4 x 4.5) + (1 x 26) + (4 x 1.5) = 50 m.

Using the queue dissipation assumption would provide the same result, 19 s, as Scenario 1 (see Appendix A.2.2.1). However, the inclusion of a non-car invalidates the assumption. A realistic queue dissipation time can instead be calculated using the method provided in ‘A Behavioural Car-following Model for Computer Simulation’, and produces a QCT of 25.5 s.

A.2.4.2 Case B

If the B-double only has to reach the intersection stop line then the distance to the back of the B-double from the intersection stop line will be 26 m.

Therefore, the travelled distance is calculated as follows:

Travelled distance = (back of B-double from the intersection stop line) - (length of B-double).

For example, back of B-double from the intersection stop line is 50 m and length of B-double is 26 m, the travelled distance is:

50 – 26 = 24 m.

The method provided in ‘A Behavioural Car-following Model for Computer Simulation’ realises a QCT of 20 s.

A.2.4.3 Case C

If the B-double only has to clear the level crossing then the distance of the back of the B-double from the intersection stop line will be:

50 – 10 = 40 m.

Therefore, the travelled distance is calculated as follows:

Travelled distance = (back of B-double from the intersection stop line, on the level crossing) − (back of B-double from the intersection stop line, clear of the level crossing).

For example, back of B-double from the intersection stop line, on the level crossing is 50 m and back of B double from the intersection stop line, clear of the level crossing is 40 m, the travelled distance is:

50 – 40 = 10 m.

The method provided in 'A Behavioural Car-following Model for Computer Simulation' realises a QCT of 16 s.

A.3 Controller settings

Appendix A.3 provides site-specific examples of detectors, phases or controller settings, to illustrate level crossing interface use in operating conditions. Controller special facility signals are described in TS 02670.2.

For details of the RIU terminology and circuitry refer to TS 06466.

A.3.1 Phasing with special facility signals

The phase following a TD can vary dependent on the site conditions and corresponding controller settings.

In the following example, during the TD, the site is operating the train phase set (‘E phase’ and ‘F phase’). When the TD is terminated the traffic controller will move from ‘E phase’ or ‘F phase’ to one of the following phases, depending on the active special facility signals:

- ‘B phase’ if XSF 2 is on and XSF 3 is off
- ‘C phase’ if XSF 3 is on
- ‘B phase’ if demanded and XSF 2 and XSF 3 are both off
- ‘C phase’ if demanded and XSF 2 and XSF 3 are both off, and ‘B phase’ is not demanded
- ‘A phase’ if XSF 2 and XSF 3 are both off, and ‘B phase’ and ‘C phase’ are both not demanded.

If there is no repeat TD, the controller will move from ‘E phase to one of the following phases:

- ‘B phase’ if XSF 2 is off
- ‘A phase’ if XSF 2 is on.

A.3.2 Minimum green interval

Minimum green interval time setting may need to be set to a longer time setting to allow vehicles queued at the level crossing time to travel past the stop line detectors before the phase terminates.

For example, when ‘B phase’ follows ‘E phase’, the ‘B phase’ minimum green interval will use a time setting which has a value larger than the normal minimum green interval.

Refer to TS 05493 for further details of phase intervals and time settings.

A.3.3 Traffic light response outputs

A.3.3.1 TSC/4 controller

The methods for control of the wait indicator outputs are different on each of the TSC/4 controllers. To avoid confusion the special purpose outputs (SPOPs) should be used instead.

The following SPOPs are sent to the RIU:

- SPOP1 – TLRL on or off control
- SPOP2 – Shunt TLRH - force off
- SPOP3 – TLRL on or off control.

A.3.3.2 PSC (TSC/3) controller

PSC (TSC/3) controllers have specific wait indicator outputs to the RIU and are assigned the following labels:

- wait indicator output 1 – TLRL on or off control
- wait indicator output 2 – Shunt TLRH - force off
- wait indicator output 3 – TLRL on or off control.

A.3.4 Operational monitoring

The following signals allow a user to remotely monitor the state of the level crossing interface operation using SCATS:

- MSS 9 – on while TD is on
- MSS 10 – on while TLR is on
- MSS 11 – on while XE is on
- MSS 12 – on while level crossing is manually operated
- MSS 16 – on while in train mode and controller in SCATS isolated mode.

RIU signals which the traffic signal controller can report to SCATS include the following:

- TDNO – train demand on
- TDNC – train demand cleared
- XENO – level crossing operating
- XENC – level crossing not operating
- TLRF – traffic light response.

A.3.5 Controller alarms

Examples of controller alarms settings are provided in Table 3. The MSS outputs are sent by SCATS.

Table 3 – Controller alarms

Alarm condition	Alarm setting
Site reverted to flashing-yellow due to train mode too long (exceeding time setting B10). TD or XE inputs have an alarm state (MSS 1 or 2 are set)	MSS 4 on while flashing-yellow and SCATS XSF 2 alarm on while flashing-yellow
TD inputs not in agreement	MSS 1 latched on and SCATS XSF 1 alarm latched on
XE inputs not in agreement	MSS 2 latched on and SCATS XSF 1 alarm latched on
XE goes on while TD is off	MSS 5 latched on and SCATS XSF 1 alarm latched on
XE remains on for at least 15 s after TD is off	MSS 5 latched on and SCATS XSF 1 alarm latched on
TD goes off while XE is on and the level crossing is not under manual control	MSS 6 latched on and SCATS XSF 1 alarm latched on
XE goes on too early – XE has turned on when TD is on but TLR is not due to be turned for at least 2 s, and the level crossing is not under manual control and the controller has not started up in ‘D phase’.	MSS 7 latched on and SCATS XSF 1 alarm latched on
XE goes on too early – XE has turned on when TD is on but TLR is not due to be turned for 2 s, and the level crossing is not under manual control and the controller has not started up in ‘D phase’.	MSS 8 latched on and SCATS XSF 1 alarm latched on

Note: There is a difference between alarm MSS 7 and MSS 8. MSS 7 detects a change in state from off to on. XE should never turn on before TLR. MSS 8 detects the on state of XE relative to when TLR should turn on. No alarm is registered until XE is on for at least 2 s, to allow for scenarios where XE may be on before TLR, such as when there is a repeat TD.

A.3.6 Alarm clearing

Alarms that are latched can be cleared remotely by turning the SCATS XSF 1 from off to on.

The alarms can be cleared locally by turning ‘alarm clear’ detector from off to on (using the input card or hand-held terminal).

Note, alarms will be cleared if the controller is restarted. An alarm will be regenerated if circumstances causing the alarm still exist.

The change in state clears the alarm, not the actual state. Therefore, if XSF 1 or ‘alarm clear’ detectors are left on, the alarms are not disabled.