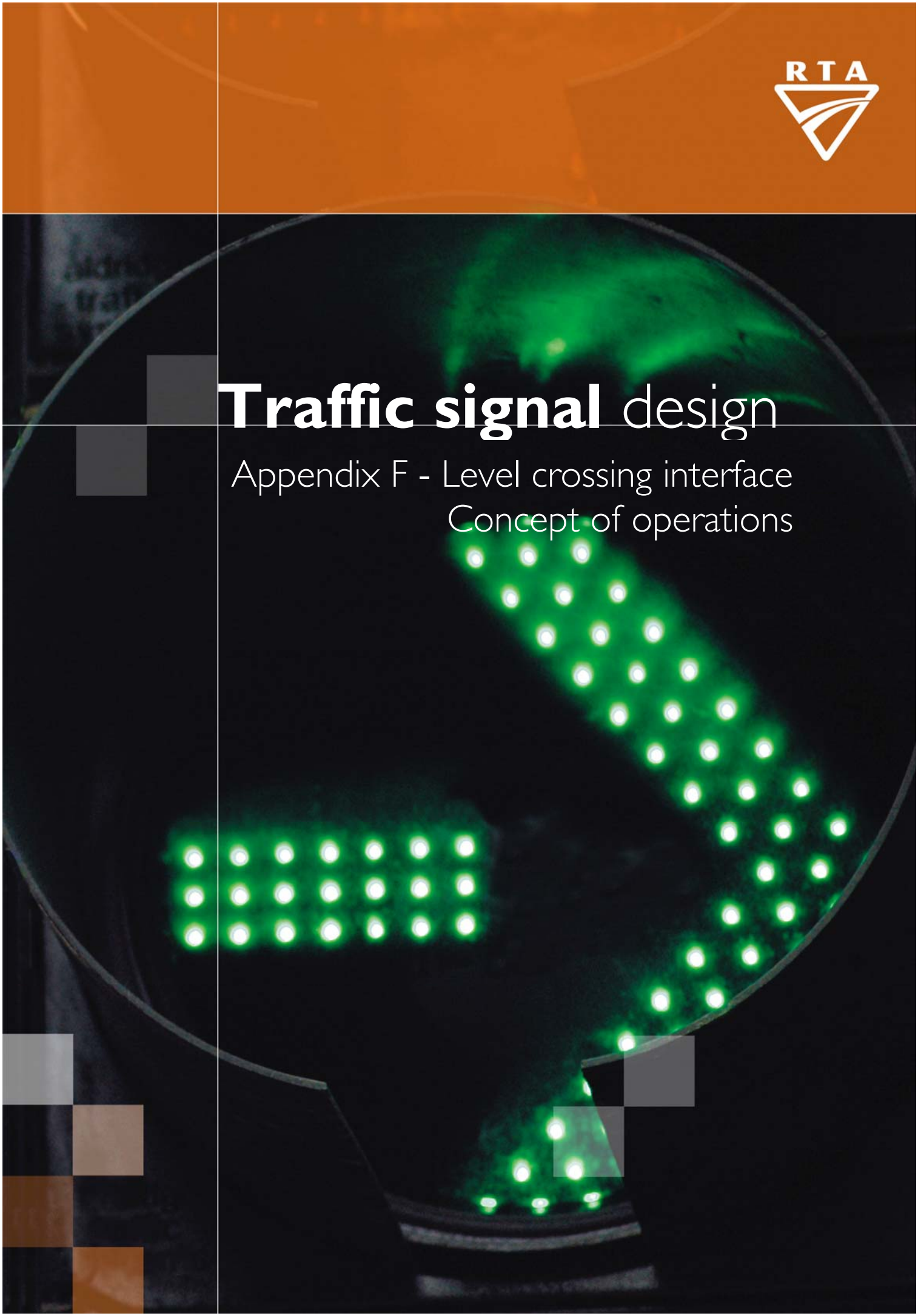

Traffic signal design

Appendix F - Level crossing interface Concept of operations

The traffic signal design guidelines have been developed to assist in designing traffic control signals.

The guidelines are to comprise 16 sections and 5 appendices. These are initially being released individually and in no specific order. The sections which are to be released are as follows:

Part	Title
Section 1	Investigation
Section 2	Warrants
Section 3	Design Process
Section 4	Plan Requirements
Section 5	Geometry
Section 6	Pavement Marking
Section 7	Phasing and Signal Group Display Sequence
Section 8	Lanterns
Section 9	Posts
Section 10	Signs
Section 11	Detectors
Section 12	Controller
Section 13	Provision for Future Facilities
Section 14	Signalised Mid-block Marked Footcrossings
Section 15	Special Situations
Section 16	References
Appendix A	Design Plan Checklist
Appendix B	Traffic Signal Symbols
Appendix C	Location and Function of Lanterns
Appendix D	Location and Dimensions of Components
Appendix E	Left Turn on Red
Appendix F	Level Crossing Interface – Concept of Operations
Appendix G	Level Crossing Interface – Traffic Signal Design Guidance

To determine which sections are currently available go to:

www.rta.nsw.gov.au/doingbusinesswithus/downloads/technicalmanuals/trafficsignaldesign_dl1.html

The information contained in the various parts is intended to be used as a guide to good practice. Discretion and judgement should be exercised in the light of the many factors that may influence the design of traffic signals at any particular site. The guidelines make reference, where relevant, to current Australian Standards and are intended to supplement and otherwise assist in their interpretation and application.

Traffic Signal Design

APPENDIX F

LEVEL CROSSING INTERFACE
Concept of Operations

Special Note:

As of 17 January 2011, the RTA is adopting the Austroads Guides (Guide to Traffic Management) and Australian Standards (AS 1742, 1743 & 2890) as its primary technical references.

An RTA Supplement has been developed for each Part of the Guide to Traffic Management and relevant Australian Standard. The Supplements document any **mandatory** RTA practice and any complementary guidelines which need to be considered.

The RTA Supplements **must** be referred to prior to using any reference material.

This RTA document is a complementary guideline. Therefore if any conflict arises, the RTA Supplements, the Austroads Guides and the Australian Standards are to prevail.

The RTA Supplements are located on the RTA website at www.rta.nsw.gov.au

Roads and Traffic Authority
www.rta.nsw.gov.au

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APPROVED BY:

SIGNED

Phil Margison
General Manager
Traffic Management

AUTHORISED FOR USE BY:

SIGNED

Peter Collins
Director
Network Management

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Version	Date	Details

1 Introduction

1.1 Purpose

The purpose of this document is to define the concept of how interfaces between rail level crossing controls and the traffic signal controller should operate irrespective of the rail authority involved (RailCorp, ARTC, RIC, etc).

1.2 Scope

While every attempt has been made to generalise the information within this document to cover the principles of operation of the interface, it cannot hope to cover all aspects of every physical configuration between rail level crossing control and an intersection traffic signal controller.

This document does not give explicit rules for governing when coordination between the rail level crossing and the intersection traffic signal controller is required. It depends on the particular configuration and layout of the site, and type and extent of vehicles using the crossing and intersection. This document provides the general principles of operation and application of a coordinated interface between the rail level crossing and the road traffic signal controller.

1.3 Definitions and abbreviations

Term	Meaning
ARTC	Australian Rail Track Corporation
gate delay	The delay from the start of the operation of the level crossing flashing lights and bells to the boom gates commencing to descend.
RailCorp	Rail Corporation, New South Wales
RIC	Rail Infrastructure Corporation
RTA	Roads and Traffic Authority
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.
TD	Train Demand – an indication from the level crossing to the traffic signal controller indicating a train is approaching. (This signal ends when the train has cleared the crossing.)
TDRT	Train Demand Response Time – the advance warning time required by the traffic signal controller of an approaching train prior to the level crossing commencing to operate. (This time allows for the traffic signal controller to transition to the train demand phase set.)
TLR	Traffic Light Response – indication from the traffic signal controller to the level crossing indicating that the traffics signal controller is ready for the level crossing to commence operating. (This signal remains active while the Train Demand signal is present.)
TMB	Traffic Management Branch
TSC	Traffic Signal Controller

Term	Meaning
XE	Crossing Operating – indication from the level crossing to the traffic signal controller indicating the level crossing flashing lights are operating.

1.4 References

[1] RailCorp – Roads & Traffic Authority, Level Crossing – Traffic Light Design Interface Agreement, 30 May 2008

[2] LX-SP-001, Level Crossing Interface – Railway Interface Unit Design

[3] LX-DG-001, Level Crossing Interface – Design Guidelines

[4] LX-IP-001, Level Crossing Interface – Railway Interface Unit Installation and Testing

[5] Traffic Signal Design, Section 15 – Special Situations

2 Background

If a traffic signal installation is located close to a railway level crossing, special provision may need to be made to reduce the likelihood that:

- queues generated by the traffic signals will not extend across the railway tracks; and
- queues generated by level crossing operation will not interfere with traffic movements at the intersection.

This may be achieved by treatments such as warning signs, escape routes, additional road widening, and control strategies that prevent formation of queues and respond promptly to queues that are detected. These strategies generally require coordination between the level crossing and traffic signals.

Figure 1 below illustrates the general situation for a rail level crossing and signalised road intersection layout. There are a number of factors which drive specific concerns on how a rail level crossing and road intersection may be required to operate. Examples are:

- Types of vehicle using the intersection and level crossing;
- General speed of transition of vehicles through the level crossing and/or intersection;
- Distance between the level crossing and the intersection;
- Drivers line of sight and resultant perception of rail and vehicle warning systems, eg signs, lights, bells.

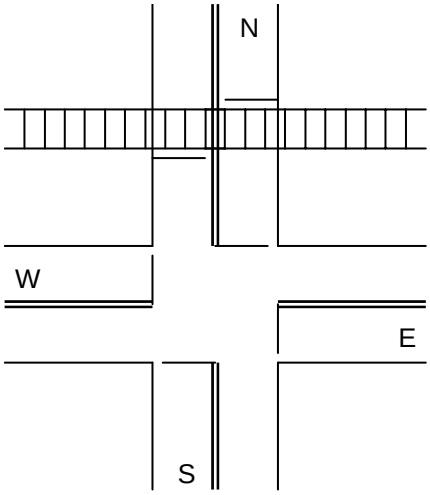

Figure 1 Example situation for rail – road interface

These translate into the following two problem types which are further described below:

- Traffic queued from the intersection stop-line back towards/through the level crossing.
- Traffic queued from the level crossing stop-line back towards/through the intersection.

2.1 Type 1

Operation of the intersection signals causes vehicles to be queued and stopped on the level crossing, due to:

- a red light; or
- congestion; or

- a pedestrian movement (controlled or uncontrolled).

Actions to alleviate problems of type 1 are:

1. Prevent queues forming across the level crossing (provide a controlling traffic signal on the approach to the level crossing).
2. Minimise queue length (provide a detector to identify queue formation and respond quickly with a green signal to dissipate queued vehicles).
3. Discharge any formed queue when a train is coming (provide a clearance phase which gives a green signal to queued vehicles when the train is coming).

2.2 Type 2

Queuing at the level crossing interferes with intersection operation. An example is where slow moving long vehicle traffic from the South (in Figure 1 above) has started to move North and the crossing starts to operate in front of them causing the vehicle to stop. This long vehicle could then compromise the intersection if it has to stop before the crossing. This can also happen for vehicles turning right from the East.

Actions to alleviate problems of type 2 are:

1. Ensure that vehicles (particularly long vehicles) will have sufficient time to clear the intersection and the level crossing before the level crossing starts operating.
2. Prevent vehicles from entering the roadway between the intersection and level crossing when the level crossing is operating.

2.3 Resolution

To overcome both problem types occurring it may be desirable to coordinate the operation of the crossing and traffic signals. If traffic signal coordination with the railway level crossing is justified the following principles should be followed:

- All traffic proceeding towards the level crossing should be stopped by traffic signals (where such signals exist).
- A special queue-clearing sequence should be initiated at a predetermined time before the train is due at the crossing if it is possibile that vehicles may be queued across the level crossing.

3 Operating Principles

This section provides the operating principles for the coordination of a rail level crossing and the intersection traffic signal controller.

3.1 General Description

There are no explicit rules for governing when coordination between the rail level crossing and the intersection traffic signal controller is required. It depends on the particular configuration, layout of the site and types of vehicles using the crossing.

In order to provide coordination, the traffic signal controller will need to have advance warning that a train is approaching. To achieve the advance warning indications should be provided by the Rail Authority to enable certain actions by the intersection controller. This advance warning is required to:

- terminate certain phases or signal groups; and
- run a clearance phase, where appropriate.

While the train is approaching and until the crossing has finished operating the intersection should run one or more phases which allow movements other than those that give vehicles authority to proceed towards the level crossing.

The interface with the railway system should include the following advance warning indications:

- A ***train demand*** signal that the railway train detection system sends to the traffic signal controller. This signal starts when a train is detected approaching the level crossing and ends when the train has cleared the crossing.
- A ***crossing operating*** signal that the railway signalling system sends to the traffic signal controller. This signal starts when crossing warning lights start flashing and ends when the warning lights stop flashing.

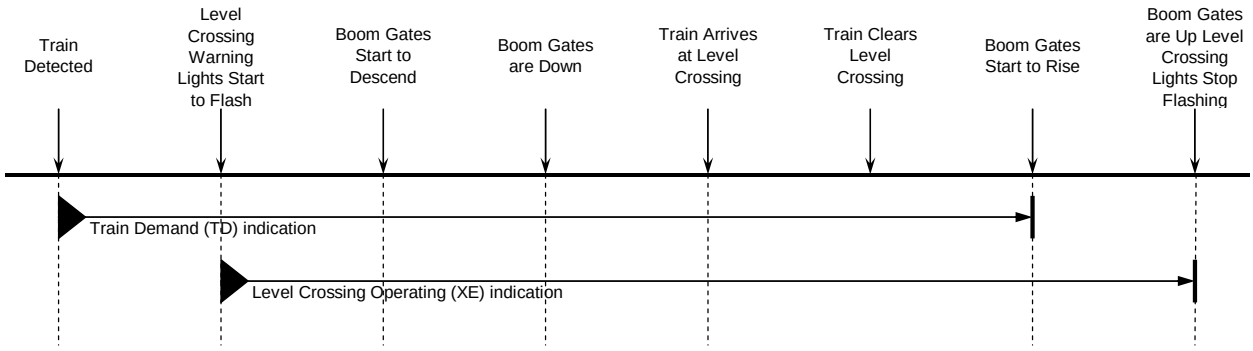

Figure 2 Train demand and crossing operating indications periods

To ensure that the traffic signals are able to respond to the ***train demand*** and put the traffic signals in a state which is satisfactory for level crossing operation the railway detection system must provide the ***train demand*** at a time in advance of the train arriving at the level crossing. This time is the ***train demand response time***.

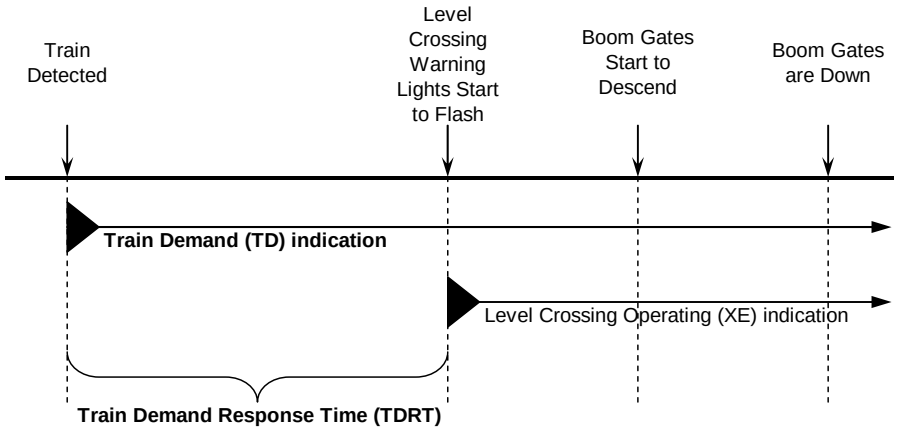

Figure 3 Train demand, crossing operating and train demand response time

To aid in the efficiency of operation for the rail network it may be beneficial for the intersection to provide an indication when the traffic signals are in a state which is satisfactory for the level crossing to commence operation. The indication is termed the ***traffic light response*** signal and is provided to the railway signalling system. This indication enables the level crossing to commence operation earlier without having to wait for the ***train demand response time*** to elapse.

The personality of the traffic signal controller should be designed to respond to the ***train demand*** signal and ***crossing operating*** signal, and send the ***traffic light response*** signal at the appropriate time.

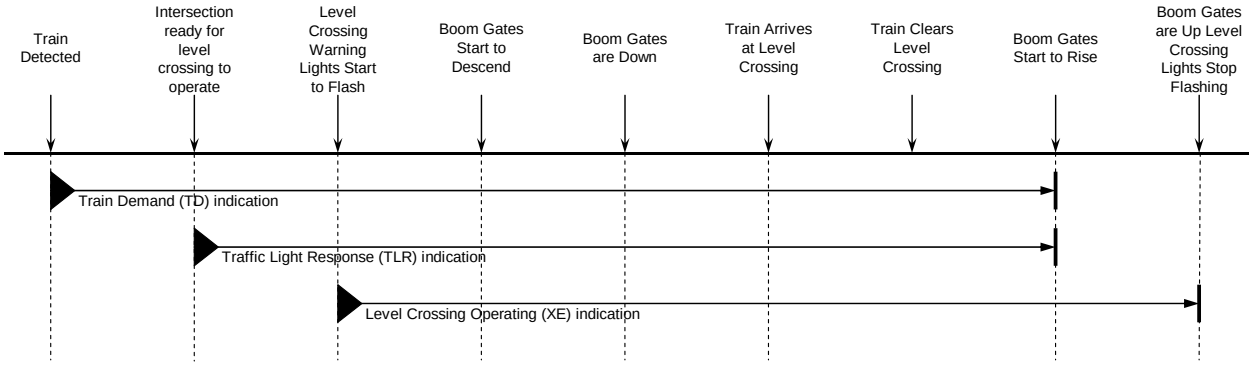

Figure 4 Train demand, crossing operating and traffic light response indications periods

The period between TLR and XE going will vary from a few 100msecs to tens of seconds, and is dependent on the following:

- whether the time taken to terminate the running phase and transition to a state where the intersection is ready for level crossing operation, is best or worse case; and
- the time taken for the rail authority to respond to TLR going on (generally small); and
- whether the train, and hence level crossing operation, is in a position to take advantage of TLR going on early.

The intersection design plan, and hence the personality, should incorporate two sets of phases;

- a normal set that the controller is permitted to run when there is no ***train demand***; and
- a ***train demand phase set*** when there is a ***train demand***.

If the controller is to transition to a ***train demand phase set*** or ***clearance phase*** when a ***train demand*** is received, the controller should be configured so that termination of the running phase is as early as possible provided that the following safety times are observed:

- a minimum vehicle green of 5 seconds;

- pedestrian clearance times as set;
- yellow times as set; and
- all red times as set.

Where there are traffic signals on the approach to the level crossing, they should display red while the ***crossing operating*** signal is present.

Red signals should be displayed to movements proceeding towards the railway crossing as soon as possible after the receipt of a ***train demand*** and while the ***train demand*** signal is present.

The controller may transition to normal operation after the ***train demand*** signal has ceased and should resume normal operation after the ***crossing operating*** signal has ceased.

3.2 Sites with a Clearance Phase

The purpose of the ***clearance phase*** is to allow vehicles that may be trapped on the level crossing to clear the level crossing before or shortly after the warning lights start flashing and, where there are boom gates, before the boom gates start descending.

During the ***clearance phase***, traffic signals should display green to vehicles that have already passed over the level crossing, and red traffic signals should be displayed to vehicles proceeding towards the crossing. Traffic signals on mast arms that can be seen from vehicles on the other side of the level crossing should be switched off during the ***clearance phase***.

After the ***clearance phase*** starts, vehicles queued between the railway line and the intersection will commence moving. The ***queue clearance time*** is the time from the start of the ***clearance phase*** required for the last queued vehicle to start moving and clear the level crossing when the queue extends back from the stop line to the railway line.

There may be an unavoidable delay from the time that a ***train demand*** is received until the traffic signal controller can start a ***clearance phase*** and remain in that phase for the ***queue clearance time***. This delay will vary from a few seconds to tens of seconds 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 ***queue clearance time***. The *maximum* ***train demand response time*** 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 ***queue clearance time***.

The ***queue clearance time*** and required ***train demand response time*** is calculated by the RTA.

The Controller Information Sheet should list all of the time settings which, if increased, could increase the *maximum* ***clearance phase*** start delay or *maximum* ***train demand response time***.

Once a ***train demand*** has been received, vehicle or pedestrian signals that conflict with the ***clearance phase*** should not be switched to green or off until after the ***clearance phase*** has ended.

If a vehicle signal that conflicts with the ***clearance phase*** is already showing green (or off) when a ***train demand*** is received, the green (or off) should be terminated if more than 5 seconds has elapsed since the start of the green (or off).

If a pedestrian signal that conflicts with the ***clearance phase*** is already showing "WALK" when a ***train demand*** is received, the "WALK" should be terminated immediately (whether the walk time has elapsed or not) and the pedestrian clearance started.

In order to reduce the ***train demand response time*** the controller may be configured to divert to the ***clearance phase*** during a phase transition.

The ***clearance phase*** may be optionally extended beyond the minimum ***queue clearance time*** to clear all vehicles queued between the level crossing and the intersection stop line.

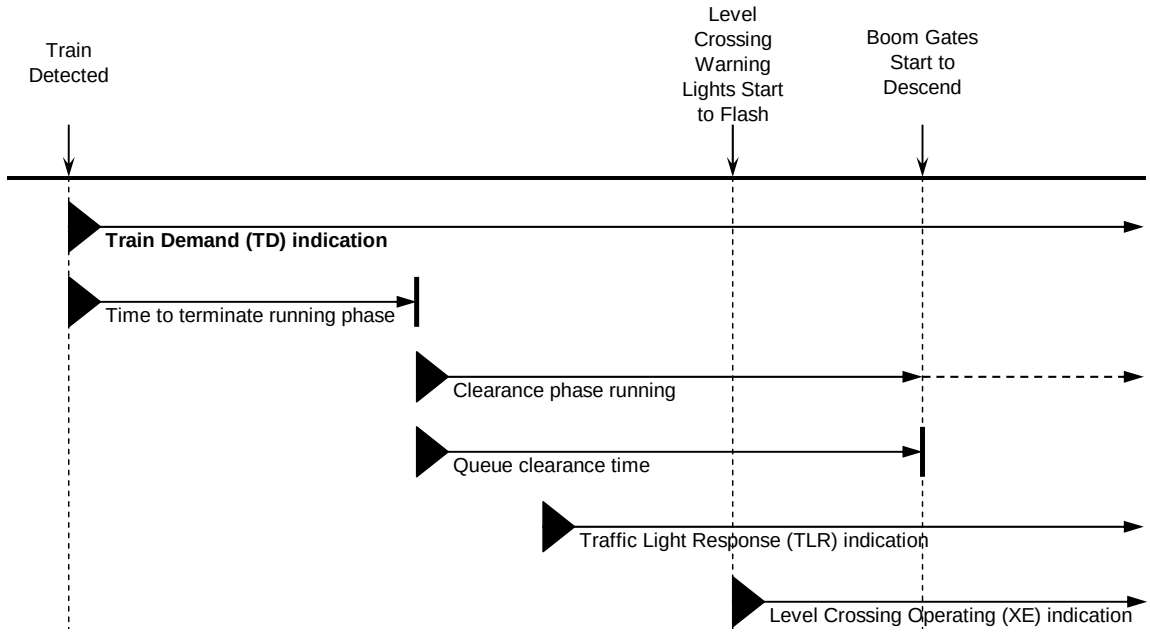

Figure 5 Clearance phase

3.2.1 Queue Clearance Time

The formulation of the ***queue clearance time*** should take into account the following aspects:

- Types of vehicle using the level crossing, eg cars, vans, lorries, B-doubles, etc.
- Distance between the level crossing and the intersection.
- Distance from any intersection stop line to the level crossing.
- Geometry/layout of the intersection, eg pavement type, horizontal alignment, vertical grades.

The ***queue clearance time*** is calculated by the RTA.

3.3 Sites without a Clearance Phase

There may be no need for a ***clearance phase*** when the railway line is very close to, or passes through, the intersection. When there is no ***clearance phase***, signals must be sequenced such that it is not possible for vehicles to be trapped.

In all instances, there may be an unavoidable delay from the time that a ***train demand*** is received until the traffic signal controller can transition to the ***train demand phase set***. This delay will vary from a few seconds to tens of seconds depending on the time taken to terminate the signal groups in the running phase and transition to a selected phase in the ***train demand phase set***. The ***train demand response time*** is the worst-case time for the traffic signal controller to terminate any running phase and move to the selected phase in the ***train demand phase set***.

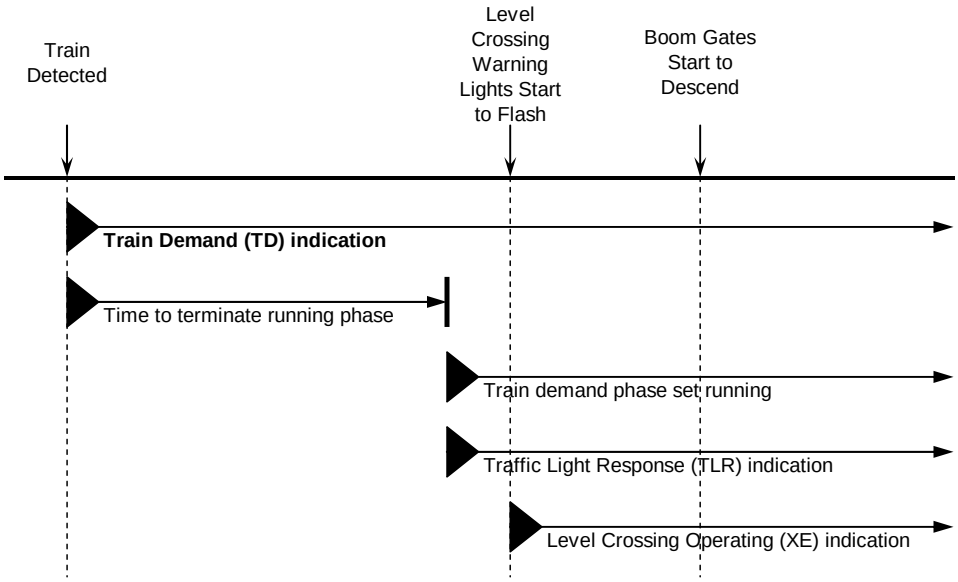

Figure 6 No clearance phase

The phase selected to run next from the ***train demand phase set*** will usually be the phase that is most similar to the phase that was running when the train demand was received. If there is no similar phase to the running phase, the phase that is most similar to the next demanded phase should be selected.

The Controller Information Sheet should list all of the time settings which, if increased, could increase the time required to respond to the ***train demand***.

Once a ***train demand*** has been received, vehicle or pedestrian signals that conflict with the selected phase in the ***train demand phase set*** should not be switched to green or off.

If a vehicle signal that conflicts with the selected phase is already showing green (or off) when a ***train demand*** is received, the green (or off) should be terminated if more than 5 seconds has elapsed since the start of the green (or off).

If a pedestrian signal that conflicts with the selected phase is already showing "WALK" when a ***train demand*** is received, the "WALK" should be terminated immediately (whether the walk time has elapsed or not) and the pedestrian clearance started.

In order to reduce the ***train demand response time*** the controller may be configured to divert to the selected phase during a phase transition.

3.4 Train Demand Response Time

The formulation of the ***train demand response time*** is vital to the correct operation of the interface. Its calculation is obtained from the combination of the following two components:

1. The time to transition to the ***train demand phase set*** or ***clearance phase***. The time is dependent on the currently running phase and movements in the traffic signal controller and its length lies somewhere between the best and worst cases:
   - The best case is where the currently running phase can be terminated and the transition to the next phase starts immediately satisfying any remaining safety times identified in section 3.1 during the transition (shortest delay); and
   - The worst case is where the currently running phase has only just been initiated and can not be terminated as one or more of the safety times identified in section 3.1 must be satisfied first (longest delay). Generally, the longest delay will be incurred when a pedestrian

movement must be terminated and clearance intervals completed before transition to the next phase can commence.

2. The ***queue clearance time***, where appropriate. The time required to clear any vehicles that may have unwisely ventured onto the rail crossing without ensuring that they could clear the crossing completely. This time depends on the possible queue length from the intersection stop line to the level crossing and the types of vehicle that would make up the queue, eg a B-double take considerably longer to move 20 metres than an ordinary car irrespective of the type of driver. Each site needs individual inspection to determine an appropriately conservative value for the ***queue clearance time.***

The ***train demand response time*** is calculated by the RTA.

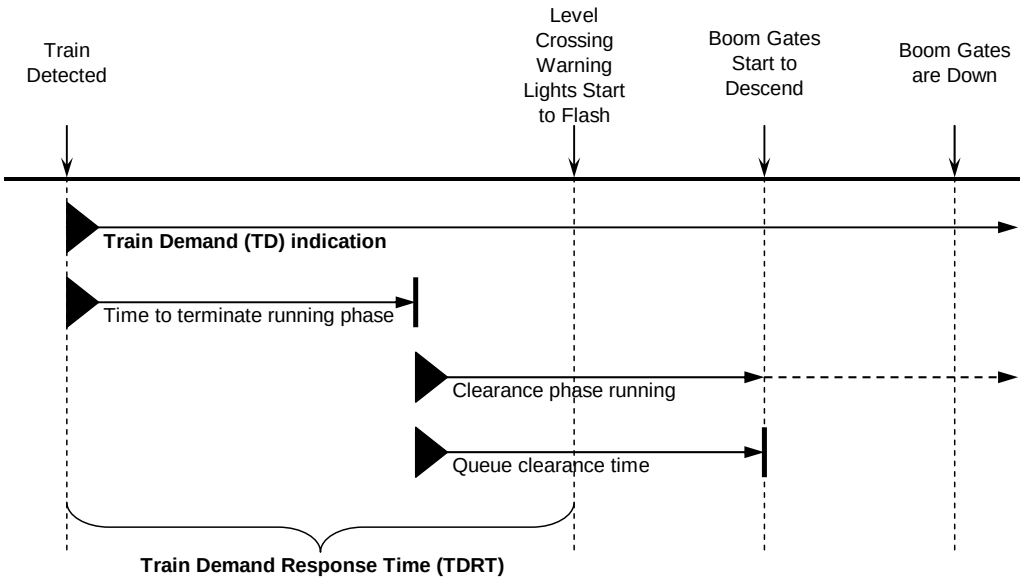

Figure 7 Train demand response time with clearance phase requirement

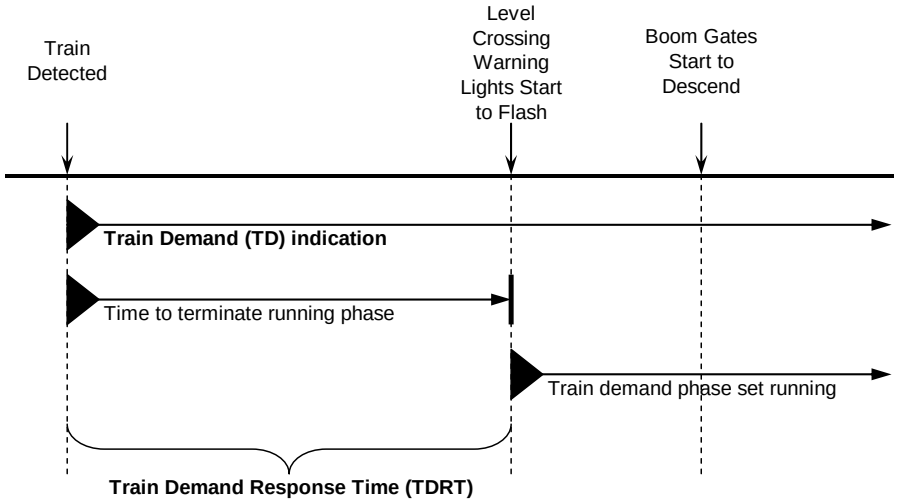

Figure 8 Train demand response time with no clearance phase requirement

3.5 Traffic Light Response

When the traffic signals are ready for the crossing to commence operating it may be beneficial for the intersection to provide an indication to the railway signalling system. This indication is termed the ***traffic light response*** signal and remains active until the train demand ceases.

The intersection is deemed to be ready when either the ***train demand phase set*** has commenced operating or the ***clearance phase*** has been running for a time equal to the ***queue clearance time*** minus the ***gate delay*** (whichever occurs earlier).

The ***gate delay*** is the delay between the commencement of the level crossing warning lights flashing and the boom gates starting to descend and is determined by the Rail Authority based on advice from the RTA concerning the types of vehicles using the level crossing.

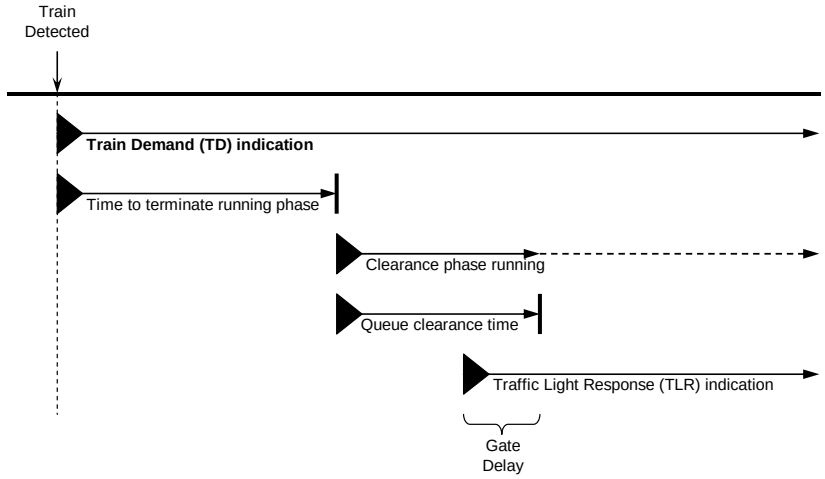

Figure 9 Traffic light response with clearance phase requirement

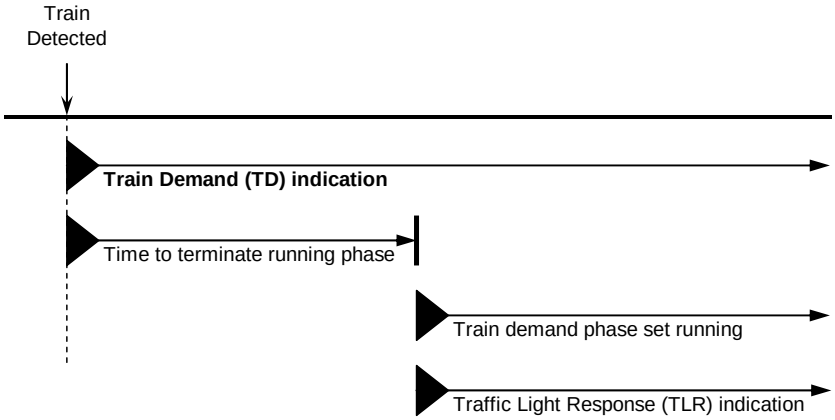

Figure 10 Traffic light response with no clearance phase requirement

3.6 Successive Operation

Where a level crossing is on a busy rail line it is reasonable to expect a second train to approach the level crossing while the first train is still passing through it. There are three general cases where successive operation is to be considered.

- The second train places a ***train demand*** while the first ***train demand*** is still in place. The traffic signal controller will not "see" a second train but a continuous demand. In this case the successive demand keeps the traffic signal controller in the ***train demand phase set*** and remains here until "both" ***train demand***s have ceased and will then begin transition to the normal set of phases when ***crossing operating*** ceases.
- The second train places a ***train demand*** shortly after the level crossing has ceased operating. In this case the successive demand is treated as a new separate demand.
- The second train places a ***train demand*** after the first ***train demand*** has been removed but while the level crossing is still operating. In this case there are two particular responses by the traffic signal controller:

1. The second ***train demand*** arrives before the traffic signal controller has removed the ***traffic light response.*** In this case the successive demand keeps the traffic signal controller in the ***train demand phase set*** and remains here until "both" ***train demand***s have ceased and will begin transition to the normal set of phases when ***crossing operating*** ceases.
2. The second ***train demand*** arrives after the traffic signal controller has removed the ***traffic light response***. In this case the railway system may have started to raise the booms and the successive demand is treated as a new separate demand.

4 Fault Monitoring and Management

A traffic signal controller interfaced with level crossing signals should be connected to SCATS to ensure that the site is monitored and alarms notified.

If the controller detects a fault in either the ***train demand*** or ***crossing operating*** circuits, the controller shall operate as if a train demand had been received.

In the event that the controller detects a fault with the ***train demand***, ***crossing operating*** or ***traffic light response*** signals a high priority alarm (e.g. SF alarm) should be generated and communicated through SCATS. SCATS should be configured to recognise theses alarms and log relevant information.

The RTA and the Railway Authority (RailCorp, ARTC, RIC, etc) should each nominate a contact person for each intersection and establish an agreed protocol for reporting problems with the operation of either system.

For further enquiries
www.rta.nsw.gov.au
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Roads and Traffic Authority

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