AS 7601.1:2021

Light rail and road interfaces Part 1: Management of light rail vehicle movement

RISSB

RAIL INDUSTRY SAFETY AND STANDARDS BOARD

Light rail Standard

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This Australian Standard® AS 7601.1 Light rail and road interfaces
Part 1: Management of light rail vehicle movement was prepared by a Rail Industry Safety and Standards Board (RISSB) Development Group consisting of representatives from the following organisations:

Altrac Light Rail	Canberra Metro	Tehnika
Rail Safety Consulting Australia	Transport for NSW	Yarra Trams
Dept. Infrastructure and Transport	Keolis Downer	Main Roads WA

The Standard was approved by the Development Group and the Enter Standing Committee Standing Committee in Select SC approval date. On Select Board approval date the RISSB Board approved the Standard for release.

This standard was issued for public consultation and was independently validated before being approved.

Development of the Standard was undertaken in accordance with RISSB's accredited process. As part of the approval process, the Standing Committee verified that proper process was followed in developing the Standard

RISSB wishes to acknowledge the positive contribution of subject matter experts in the development of this Standard. Their efforts ranged from membership of the Development Group through to individuals providing comment on a draft of the Standard during the open review.

I commend this Standard to the Australasian rail industry as it represents industry good practice and has been developed through a rigorous process.

Deb Spring
Exec. Chair / CEO
Rail Industry Safety and Standards Board

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Part 1: Management of light rail vehicle movement

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This Standard was prepared by the Rail Industry Safety and Standards Board (RISSB) Development Group AS 7601.1 Light rail and road interfaces
Part 1: Management of light rail vehicle movement.

Membership of this Development Group consisted of representatives from the organisations listed on the inside cover of this document

Objective

This Standard provides a consistent approach to the use of signals used in the operation of light rail networks. This Standard specifically covers signalling used on light rail networks. This Standard does not provide guidance or instruction on road signals used for road traffic purposes.

This Standard applies to new networks and may be applied against existing light rail and modified light rail networks.

This Standard is part of the AS 7601 (Light rail and road interfaces) series. This series is currently under development.

Compliance

There are four types of provisions contained within Australian Standards developed by RISSB:

1. Requirements.
2. Recommendations.
3. Permissions.
4. Constraints.

Requirements – it is mandatory to follow all requirements to claim full compliance with the Standard. Requirements are identified within the text by the term 'shall'.

Recommendations – do not mention or exclude other possibilities but do offer the one that is preferred. Recommendations are identified within the text by the term 'should'.

Recommendations recognise that there could be limitations to the universal application of the control, i.e. the identified control is not able to be applied or other controls are more appropriate or better.

Permissions – conveys consent by providing an allowable option. Permissions are identified within the text by the term 'may'.

Constraints - provided by an external source such as legislation. Constraints are identified within the text by the term 'must'.

For compliance purposes, where a recommended control is not applied as written in the standard it could be incumbent on the adopter of the standard to demonstrate their actual method of controlling the risk as part of their WHS or Rail Safety National Law obligations. Similarly, it could also be incumbent on an adopter of the standard to demonstrate their method of controlling the risk to contracting entities, or interfacing organisations where the risk may be shared.

Controls in RISSB standards address known railway hazards, and are detailed in Appendix A.

Contents

Appendix Contents

1 Scope and general

1.1 Scope

This Standard specifies the minimum requirements for design, interpretation and use of visual driver cues and signalling systems that permit the safe movement of light rail vehicles in light rail networks. This includes:

(a) line of sight operation;

(b) pavement markings or stud markings;

(c) traffic signals;

(d) light rail signals;

(e) other indicators.

This Standard applies to all light rail networks, excluding heritage and tourist tramways. Heritage and tourist tramways may adopt this Standard if they deem appropriate to do so.

1.2 Exclusions

This Standard does not address:

(a) electrical requirements for return traction currents;

(b) signals mounted on light rail vehicles such as indicators and brake lights;

(c) control of vehicle movements, other than light rail vehicle movements, by road traffic control systems;

(d) level crossings systems used on light rail networks.

1.3 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document:

- AS 1742.14 Manual of uniform traffic control devices: Traffic signals
- AS 2144 Traffic signal lanterns
- AS 7470 Human factors integration in engineering design – General principles
- AS 7663 Railway signal cables
- AS 7664 Railway signalling cable routes, cable pits, and foundations
- AS/NZS 3000 Wiring rules
- IEC 61508-1 Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 1: General requirements

NOTE: Documents for informative purposes are listed in Appendix H - Bibliography .

1.4 Terms, definitions, and abbreviations

For the purposes of this document, the following terms and definitions apply:

1.4.1
light rail network

passenger-carrying rail network operating with light rail vehicles or trams, typically used in urban areas and often having a shared right-of-way with road traffic employing line of sight methods to control movements

1.4.2
light rail manager[1]

authority or body responsible for the care, control, or management of the light rail network

1.4.3
light rail signal

signals, excluding T-Lights and other traffic signals, used to direct the safe movement of an LRV

1.4.4
LRTAE[2]

light rail vehicle exceeding the limit of the permitted movement. Also referred to as a light rail or tram authority exceedance

1.4.5
light rail vehicle

LRV

vehicle, including trams, used to transport passengers on a light rail network

1.4.6
light rail vehicle driver

LRV driver

person who operates a light rail vehicle

1.4.7
line of sight

movement of an LRV where the LRV driver controls the speed of the LRV to maintain, in all circumstances, a safe distance from any obstruction with respect to braking capability (excluding emergency brake applications)

1.4.8
pavement marking

markings, raised pavement markers, traffic domes and the like placed on the road to control traffic movement or parking[3]

1.4.9
RAM

reliability, availability, maintainability

[1] Also referred to as Rail Transport Operator, as defined in Rail Safety National Law
[2] As defined in the Reporting Requirements for Notifiable Occurrences Guideline June 2019, ONRSR
[3] As per Austroads Glossary of Terms (2015 Edition)

1.4.10
road crossing[4]

location where a road and light rail track meet substantially at grade, no level crossing signage is used on any of the approach roads and LRV's are operated in accordance with road rules and controls. Commonly referred to as a road intersection

1.4.11
road manager

national or state road agency, municipality, other body or individual responsible for the care, control, and maintenance of road infrastructure

1.4.12
running lines

light rail track used for through movements, as distinct from depots

1.4.13
shared corridor

area where light rail vehicles share the roadway with road and pedestrian traffic

1.4.14
stop line

location where a LRV is required stop until a following condition is fulfilled

1.4.15
T-Light

traffic signal aspect for the exclusive control of trams, light rail, or cane railway trains.

1.4.16
tram stop

place on a road at which there is a sign indicating that trams will stop to enable people to get on or off.

1.4.17
traffic signal

signal that controls vehicle and pedestrian traffic at an intersection or on a road by means of red, yellow, green or white light displays, and includes circular and arrow signals, pedestrian signals, bicycle crossing signals, B (bus) and T (tram) signals, overhead lane control signals, and twin red or yellow signals. crossings

1.4.18
traffic signal controller
TSC

automatic device that regulates the sequence and duration of the illumination of aspects

General rail industry terms and definitions are maintained in the RISSB Glossary: https://www.rissb.com.au/products/glossary/

[4] Term road crossing used in Rail Safety National Law

2 General principles

The management of safe movement of light rail vehicles (LRVs) involves reducing the risk of:

(a) collision between light rail vehicles (Section 4, 5 and 6);

(b) collision between light rail vehicles and road users (Section 4 and 5);

(c) collision between light rail vehicles and pedestrian traffic (Section 4 and 5);

(d) derailment (Section 6 and 7);

(e) inadvertently proceeding through incorrectly set routes (Section 6 and 7).

Management of the above risks is achieved through a combination of line-of-sight, pavement or stud markings, traffic signals, light rail signalling systems and other safety systems.

The simplest effective means of route authority should be used for the movement of light rail vehicles. Further detail is provided in section 3.

A suggested terminus location layout is provided in Appendix F.

3 Movement permissions

3.1 General principles

The principal method of ascertaining whether it is safe to move an LRV shall be the line-of-sight method as described in Section 4.

LRV movement within shared corridors such as roadways must be in accordance with road legislation applicable to light rail vehicle movement.

An LRV driver shall only move a LRV once line of sight requirements have been met.

Line of sight may also be achieved in conjunction with one of or a combination of the following methods:

(a) Pavement or stud markings.

(b) Traffic signals.

(c) Light rail signals.

(d) Turnout indicators.

Yard management systems may use a combination of the above methods to manage LRV movements in, out and within depots.

Closed circuit television monitoring may be used as a supplementary system to assist assessment of whether it is safe to move an LRV.

Any methods used including line of sight should be designed to avoid any unnecessary complexity. Suggested movement methodologies are provided in Appendix C.

Where multiple movement permission systems are used the hierarchy of those systems shall be clearly defined.

3.2 Movement permission selection

Line of sight shall be the primary movement permission system. Where the risk of collision or derailment cannot be reduced to safe so far as is reasonably practical (SFAIRP) then additional systems shall be used, such as pavement or stud markings, traffic signals, light rail signals and turnout indicators.

Selection of a movement permission system, or combination of systems, should consider the following as a minimum:

(a) Sighting distances.

(b) Intended and reasonably likely speed of operation.

(c) Braking performance of the LRV, taking into account the gradient and LRV brake equipment response time.

(d) Effectiveness of the LRV headlamps, if it is intended to operate in darkness in unlit areas, or the effectiveness of any illumination of the track.

(e) Expected driver reaction time, which will depend upon what other actions the driver is expected to be carrying out at the location.

(f) In shared corridors, clearances from and speed of adjacent road traffic.

(g) Visibility and clarity of signals and turnout indicators.

(h) Tunnels or undercover lines.

(i) Geometry of the tramway alignment.

(j) Provision of any form of active warning system, such as speed and proximity monitoring systems.

(k) Consequences of failure of the selected system.

(l) How the road corridor is used, such as the presence of heavy vehicles, general traffic, cyclists, pedestrians, etc.

3.3 Human factors

3.3.1 General requirements

Light rail systems operate in dynamic environments, where a LRV driver can be subjected to a high cognitive workload, and multiple vehicle and human interactions. Human factor risks shall be identified, analysed, and mitigated safe SFAIRP as part of the design phase.

The principles in AS 7470 should be applied when conducting any human factors assessment.

Human factors assessments should include consideration of:

(a) the needs of all users of the location (LRV driver, pedestrians, cyclists and road traffic);

(b) visibility and sighting (including time of day effects, environmental factors);

(c) use of signals, including location, type, clutter, etc;

(d) habit intrusion, expectations, and distractions (refer Appendix B.1);

(e) operation of the LRV, including driver workload;

(f) potential operational changes due to maintenance, degraded operations, or emergency situations.

3.3.2 Task and error analysis

A task and error analysis should be conducted from the perspective of each user of a light rail network. This analysis should be used when considering design of a light rail system, with the aim to making the system error tolerant SFAIRP.

The task and error analysis can assist in designing a system that ensures the visual messages are clearly seen, identified and understood. This may be achieved by:

(a) reducing visual clutter;

(b) reducing potential visual conflicts, including conflicting signal indications;

(c) standardization of indications;

(d) standardization of signal position (refer Appendix B.2).

Further information on assessment of human factors such as error tolerance is provided in AS 7470.

4 Line of sight

4.1 General principles

Line of sight movement is operated under visual conditions that enable the LRV driver to see sufficient distance ahead to maintain a safe distance from any preceding light rail vehicle or maintenance vehicle, as well as any road vehicle, pedestrian, cyclist or obstruction in respect to the LRV speed and braking capability.

4.2 Design

Light rail network design should consider that line of sight movement will only take place when:

(a) the variable situational risks and conditions have been assessed;

(b) line of sight requirements are confirmed;

(c) there is no obstruction within the clearance gauge;

(d) a safe distance can be maintained (see clause 4.3);

(e) the LRV is in a safe condition to move;

(f) the location where the vehicle is being moved to will not constitute a risk to other LRV's or road users.

Safeworking rules and procedures within each individual network provide further guidance for LRV drivers.

4.3 Safe distance

The minimum safe distance shall be specified in the light rail system design, network rules and procedures. The safe distance permitted should consider:

(a) LRV speed;

(b) sighting distance;

(c) braking capacity;

(d) visibility;

(e) environmental conditions;

(f) any other identified parameters that can affect the ability to stop a light rail vehicle in a safe manner.

4.4 Single line sections

To avoid the risk of collision line of sight movement permission shall not be used as the only form of movement management on bi-directional single running lines, unless the LRV driver can confirm the single line section is clear of other LRV/s or road users.

5 Pavement markings and stud markings

Pavement and stud markings provide a visual point of reference for LRV drivers. These markings advise the LRV driver of the need to stop prior to a further condition being met.

Pavement and stud markings may be used to indicate the:

(a) stop location at traffic signals;

(b) need to stop and check turnouts before proceeding;

(c) end of trafficable track;

(d) fouling or clearance locations;

(e) shunting or turnback locations;

(f) power cut off / cut in locations.

Further guidance is provided in AS 1742.2 and AS 1742.12

6 Road crossings

6.1 General principle

LRVs can operate across road crossings equipped with traffic signals. Road crossings include road intersections and locations where pedestrians cross light rail at controlled locations.

Road crossings are not to be confused with level crossings which are used in some light rail networks and are identified in light rail networks by level crossing signage and traffic control devices such as boom gates and bells.

Movement of LRVs through road crossings shall be managed by traffic signals. An LRV driver shall only move an LRV through an intersection when:

(a) a permission to move aspect is shown on the traffic signal; and

(b) the requirements for line-of-sight movement are confirmed.

Traffic signal controller logic and control functions are designed, installed and maintained by road managers and are not included in the scope of this Standard.

6.2 Type of traffic signals

Traffic signals shall be of a type specified in AS 1742.14 and AS 2144.

T-lights, arrows and other indications should only be used at road crossings when:

(a) LRV movement can be separate to road traffic movement; and

(b) a solid light traffic signal does not provide sufficient information to permit safe movement through the road crossing.

Other indications may be used where safe SFAIRP principles have been applied and agreement is made between stakeholders.

6.3 Traffic signal location

Traffic signals for LRVs shall be identified as being primary, secondary, or tertiary, in accordance with AS 1742.14.

Traffic signals shall be located in accordance with AS 1742.14.

For the avoidance of doubt, when applying this terminology to light rail systems the following applies:

(a) Primary – located adjacent to the stop line or designated location which a light rail vehicle shall not pass until permitted to do so. Primarily used by approaching light rail traffic.

(b) Secondary – located beyond the stopping point, usually on the far side of the intersection. Primarily used by light rail traffic stopped at an intersection.

(c) Tertiary – located as required to improve sighting of traffic signals.

Repeater traffic signals may be used where a LRV driver is unable to clearly see the primary or secondary traffic signals.

To avoid cognitive overload and signal clutter tertiary and repeater signals should only be used where required to improve signal sighting.

Traffic signals shall be placed so they can be clearly identified by the LRV driver.

Primary signals should be placed on the left side of the light rail track.

Traffic signal positions and facing shall comply with AS 1742.14.

LRV drivers should be provided training to identify which traffic signals are primary, secondary, tertiary and repeater, and the correct process to identify and manage failure of the respective types.

6.4 Phasing and sequencing

6.4.1 General

The phasing of traffic signals is controlled by the applicable TSC.

Phasing and sequencing of traffic signals shall be in accordance with the risk assessments, detailed risk controls, protocols and standards as documented between the road manager and light rail manager.

To assist the TSC in selecting the most suitable phase, information should be provided by the light rail system. This information may be provided by inputs as detailed in section 6.5.

Design of phasing systems should comply with Guide to Traffic Management Part 9: Transport Control Systems – Strategies and Operations.

6.4.2 Timing

This clause applies to LRV operating in shared corridors (with road vehicles) but may be used to assist in developing suitable phase timings for LRV operating in independent (without road vehicle) corridors that interface at road crossings.

The timing between phases is calculated in accordance with Guide to Traffic Management Part 9: Transport Control Systems – Strategies and Operations.

Phase timings are generally based on road vehicle performance. Where light rail vehicles traverse road crossings additional allowances shall be made for:

(a) lower acceleration and deceleration rates of light rail vehicles combined with vehicle length (compared to the normal vehicles that road authorities could have baselined intersection clearance time on);

(b) presence of infrastructure which limits the light rail vehicle speed through crossings; and

(c) intersection function/design/layout and associated risk if a light rail vehicle does not clear the intersection correctly.

Calculations for additional allowances should be based on light rail vehicle dimension, acceleration and braking data as supplied by the OEM, and infrastructure performance data as supplied by the infrastructure designers/operators.

When establishing phase timings at crossings where collision risk exists, road authorities should consider providing technology solutions to detect adverse presence of light rail vehicles in crossings and extend times using appropriate detection systems when this occurs.

6.4.3 Priority phasing for LRV

LRV drivers approaching traffic signals could receive late notification of a change of traffic signal phase. This is a safety risk, as the LRV driver will have to either apply an emergency brake (causing possible injury to travelling passengers) or have an LRTAE. This risk may be mitigated through extended phase timings (see section 6.5.2), giving an LRV priority to travel safely through the intersection.

The TSC achieves this by detection of an approaching LRV and providing priority (holding the phase in its current state) to allow the LRV to travel through the intersection.

When assessing whether to use priority phasing the following should be considered:

(a) TSC set up and phasing.

(b) Impact on road traffic flow and movement using traffic modelling.

(c) Environmental and timetabling benefits.

(d) Human factors associated with driver performance and system safety requirements

6.4.4 Priority phasing design

Priority phasing shall be designed so that additional hazards are not introduced into the light rail network. For this to be achieved the following applies:

(a) The light rail network shall provide inputs into the TSC using one of the methods described in section 6.5.1 of this Standard.

(b) The clear phase displayed by the traffic signal shall remain until the LRV has completely entered the intersection or a defined time period has elapsed.

(c) The LRV driver should be able to clearly identify when the LRV is within the priority zone.

Where is it possible for two LRV to approach the same road crossing from opposing directions, priority for each LRV should be independently assessed by the TSC.

6.4.5 Advance priority signals

Advance priority signals provide an LRV driver with an indication that the traffic signals will change to a clear phase within a predetermined period. This allows the LRV driver to maintain speed on approach to an intersection which could be showing a stop indication.

This form of priority signalling requires the LRV driver to make an assumption based on experience and knowledge of the phasing system. Failure to correctly judge the phase timing can result in a LRTAE and potentially a collision with another LRV or road vehicle.

Light rail networks shall be able to demonstrate how this risk is managed SFAIRP.

Advance priority signals should use either a:

(a) A-light; or

(b) triangular white light.

Other indications may be used, provided they do not conflict with AS 1742.14. and can be clearly identified as priority signals.

Priority signal indications shall be consistent throughout the light rail network.

6.5 Interface design

6.5.1 General

Light rail systems can provide inputs to the TSC.

Inputs may be provided through:

(a) detection systems such as track circuits or axle counters;
(b) inductive loops;
(c) GPS location systems;
(d) remote control centres;
(e) radio frequency identification;
(f) passive proximity technologies;
(g) priority transponder loops;
(h) turnout detection systems;
(i) manual (pushbutton) systems;
(j) any system that meets the safety and functionality requirements of the light rail system.

6.5.2 Traffic system control detection interface

Detection system inputs to the TSC should be provided:

(a) in advance of the intersection;
(b) at or adjacent to the stop line;
(c) when the LRV enters the intersection;
(d) when the LRV exits the intersection or detection zone;
(e) when the LRV registers its command for turnout selection or priority;
(f) using push buttons or other manual system when system is in a degraded operation.

Other inputs may be provided to provide effective traffic management.

6.5.3 Traffic system control input location considerations

The designed location of advance and approach inputs should consider:

(a) LRV speed;
(b) LRV braking capacity;
(c) phase timing at intersection;
(d) approach of LRVs from both directions (double line sections);
(e) stopping locations;
(f) design and positioning to prevent interference from light rail operations and electromagnetic interference
(g) any constraints designed to prevent conflicts in LRV passing.

Diagrams explaining detection associated with phase priority are provided in Appendix G.

6.5.4 Phase requests

Light rail systems should be designed to allow a phase to be requested as required. This request may be provided by the LRV being detected on approach to the road crossing or through a call placed by the LRV driver.

An option to cancel the phase request may be provided.

Light rail systems shall include the ability to provide inputs to the TSC when the LRV detection or inductive loop system is in a degraded mode.

6.5.5 Crossings with adjacent tram stops

To reduce the impact to road traffic a LRV should have a means to manually provide a traffic signal request input when the LRV is ready to depart the tram stop.

7 Light rail signalling

7.1 General principle

This Section applies only to light rail signals. Traffic signals, including T-lights, are covered in Section 6 of this Standard and AS 1742.14. Turnout indicators which are not used to indicate a movement permission are covered in Section 8.3.

The principal function of a light rail signalling system is to allow the safe movement of light rail vehicles in dedicated reserves where higher speed could be permitted, or in complex track areas, such as junctions or depots. Signalling systems may be used to improve operational efficiencies in high LRV traffic areas.

The signalling system shall be designed to reduce the risk SFAIRP of:

(a) collision between LRVs;

(b) collision between LRVs and road vehicles, pedestrians, and other road users;

(c) derailment;

(d) misrouting;

(e) unnecessary impact to road traffic; and

(f) damage to turnouts and other trackwork.

Rail signalling work must be performed in accordance with the requirements of the *Rail Safety National Law*.

7.2 Design principles

Light rail signalling systems shall be designed to provide:

(a) explicit and consistent information to enable the light rail vehicle driver to control the vehicle within the conditions set by the indication provided;

(b) fail-safe functionality, such that any predictable type of failure of an item of signalling equipment does not lead to increased risk;

(c) maintainability of the system, such that the system can be maintained safely without creating unsafe situations for the public and maintainers;

(d) vandal proof protection SFAIRP;

(e) safety integrity level (SIL) rating of equipment and applications commensurate with the required safety levels. This determination shall be made by a risk assessment in accordance with SFAIRP principles during the design phase.

Vital signalling systems should achieve a minimum level of SIL 2.

Safety requirements should be developed in accordance with IEC 61508-1.

7.3 Cyber security

Light rail signalling systems shall be designed to minimise the risk of cyber security attacks.

Guidance on cyber security for rail systems is provided in AS 7770 and Code of Practice – Rail Cyber Security for Rolling Stock and Train Control Systems.

7.4 Identification

Signals shall be uniquely identified.

Signals shall have identification numbering and lettering clearly displayed on the signal post or surround.

7.5 Location

7.5.1 General

Light rail signalling shall be used where the risks outlined in Section 2 cannot be reduced to safe SFAIRP. This may include junctions where complex turnouts exist, or where multiple LRV movements could increase the risk of collision.

Light rail signals should be located in a consistent manner across the network. For example, this may include signals being located on the same side or at the same height across the light rail network.

Light rail signals shall not be co-located on the same post as traffic signals.

7.5.2 Sighting

The minimum sighting distance should be calculated based on:

(a) LRV maximum speed;

(b) LRV service braking capabilities;

(c) LRV driver reaction time;

(d) LRV drivers direct line of sight.

Light rail signals shall be located so they can be clearly identified by the LRV driver from the;

(e) driver's normal eye position; and

(f) minimum sighting distance.

Repeater or advance signals may be used where a LRV driver is unable to clearly see the primary light rail signal.

To avoid cognitive overload and signal clutter tertiary and repeater signals should only be used where required to improve signal sighting.

Further guidance on sighting distance is provided in AS 7631[5] and AS 1742.14[6]

7.6 Signal indications

7.6.1 General

The principal function of signalling indications, as part of a system of safeworking, is to communicate permission to an LRV driver to move over a predefined section of track. Signals may also indicate the route direction at a set of turnouts.

7.6.2 Movement permission indications

In locations where light rail signals and traffic signals co-exist there is a risk that an LRV driver could move an LRV based on sighting one signal whilst inadvertently failing to sight the other signal, resulting in a LRTAE and possible collision with road users.

Where light rail and traffic signals co-exist, light rail signalling systems should avoid conflicting indications between traffic signals and light rail signals. This is best achieved by limiting light rail signal installation to areas without traffic signals. Where this cannot be achieved a system of interlocking should be implemented between the light rail signalling system and the TSC to prevent conflicting signal indications.

LRV shall only proceed past a light rail signal where:

(a) a permission to move indication is shown on the signal;

(b) the LRV driver can confirm the line of sight is clear and safe; and

(c) where applicable, points are set for the correct route.

Light rail systems shall have procedures in place for passing light rail signals in line with safe SFAIRP principles when the above requirements cannot be met. These procedures should include how an LRV driver manages the failure of traffic signals when operational light rail signals exist.

7.6.3 Types of signal indications

Multiple signal indications and types can be confusing, particularly when multiple indications show different route authorities. This can be exacerbated when light rail signals are combined with traffic signals.

Light rail signal indication types shall comply with those provided in appendix D.

7.7 Detection systems

7.7.1 General requirements

The requirements for detection systems shall be specified and documented, based on risk assessments, operational requirements, and safety in design principles.

[5] AS 7631 provides requirements and recommendations for signal sighting for heavy rail systems, and therefore is only referenced in this Standard for informative purposes.
[6] AS 1742.14 provides detailed requirements and recommendations for traffic signal sighting and may be useful when assessing light rail signalling locations.

LRV detection systems used in conjunction with light rail signals shall:

(a) be suitable for the requirement of the system requiring the detection;

(b) reliably detect the location of LRVs;

(c) be tamper and vandal proof;

(d) be designed and maintained in accordance with an agreed cyber security management plan;

(e) not be affected by road or pedestrian traffic;

(f) operate reliably in reasonably expected environmental conditions;

(g) have protection against external electromagnetic forces; and

(h) be suitable for the local environmental conditions.

7.7.2 Reliability and SIL rating

The reliability and overall RAM targets with which LRV detection systems detect and indicate the presence, absence, or passage of LRVs shall be consistent with the risk assessments, controls, and overall safety performance targets for the light rail system of which they form part of.

The risk assessments, controls and safety performance targets should take into consideration the purposes for which the LRV detection is required to be used and the possible consequences of an error in the detection.

The risk assessments, controls and safety performance targets should be used when deciding whether a SIL rated system is required, and if so what level of SIL is to be achieved. See section 7.2

7.7.3 Light rail vehicle detection

7.7.3.1 General detection requirements

Light rail vehicle detection systems shall detect all LRVs used on the light rail system.

Depending on the type of detection used and the performance criteria other vehicles, such as road/rail vehicles, are not always detected by these systems. Policies and procedures shall be developed for the operation of vehicles other than LRV where detection systems are used for vital signalling systems.

When new or altered LRVs are introduced into a light rail system they shall be tested against the existing detection systems to ensure that the detection system will reliably detect the new or altered LRV.

7.7.3.2 Track circuits

LRV detection for track circuits is the result of one or many axles making effective electrical contact with the surfaces of rails, providing a low-impedance path and thereby depriving a correctly adjusted receiver / relay of energy.

LRV detection systems which depend on electrical contact between wheelsets and rails shall have a determined minimum shunt sensitivity over the entire length of the track section apart from interface zones between adjacent track sections (electric separation joints) or permissible dead zones.

Track circuits can be unreliable as a detection method due to various issues such as light weight of vehicles and contamination of the railhead. Track circuits shall not be used as the only detection method where risk assessments require positive detection for safety critical functionality. Further information is provided in RISSB Guideline Management of Traffic with Unreliable Track Circuits.

An integral time delay shall be incorporated in the track circuit detection system to prevent output of a track clear indication resulting from a brief loss of detection during the passage of a LRV through the track section.

Other detection systems may be used in conjunction with track circuits to provide a secondary detection system.

7.7.3.3 Mass detection systems

Mass detection systems rely on resonant frequency loops to detect LRV presence.

Mass detector systems may be used as secondary protection systems for track circuits to provide fully independent detection of LRV position. Mass detection systems may be used as the primary detection system where a risk assessment deems the risk is safe SFAIRP.

Mass detectors are prone to desensitization by metallic components. Mass detection systems shall be installed and tuned to optimise detection sensitivity. They are also prone to environmental drift and should be installed with compensation circuits.

7.7.3.4 Blocking circuits

Blocking circuit detection uses a combination of wheelshunt and vehicle mass. A blocking circuit recognises the entry of rail vehicles passively by the wheelshunt produced and it recognises exiting vehicles by the reduction in vehicle mass detected. As the blocking circuit functions without insulated rail joints, its effective range is limited by short circuit connectors.

Blocking circuits, as a combination of track circuit and mass detection systems, should comply with section 7.7.3.2. and 7.7.3.3. of this Standard.

7.7.3.5 Axle counters

Axle counter systems are used to detect the number of axles that enter and/or exit a defined section of track using wheel sensors mounted to the rail.

When placed at the entrance and exit to a track section axle counters can be used to identify whether a track section is clear of detectable light rail vehicles.

Axle counters used on shared corridors shall be suitable for use in roadways.

When utilising axle counters in paved surfaces consideration should be given to the effects of rail spall and road debris.

Axle counters shall be able to be replaced without damaging the rail to which they're attached, or the roadway in which they are situated.

Further guidance on axle counters is provided in AS 7651[7].

[7] AS 7651 provides requirements and recommendations for axle counters in heavy rail systems, however, may also be adopted in part or full for other systems such as light rail.

7.7.3.6 Other detection systems

New technologies and systems not referenced in this Standard such as onboard based detection systems may be used, provided they meet the requirements of Sections 7.7.1, 7.7.2 and 7.7.3.1 of this Standard.

7.8 Cables

Signal cables should comply with AS 7663.

7.9 Cable routes

Signal cable routes shall comply with separation requirements as per AS/NZS 3000.

Signal cable shall be run in conduit.

Signal cable conduit shall have a minimum cover as specified in AS/NZS 3000.

Signal cable conduit should, as far as reasonably practical:

(a) follow a straight-line route;

(b) be located and installed between cable pits so that it does not divert or interfere with any drainage (railway or natural) or underground services;

(c) be located to avoid areas subject to potential damage due to flood wash outs, scouring or similar events.

To assist in identification, as part of the construction of the cable route, GPS mapping of cable routes should be undertaken.

Signal cable conduit should meet the specifications as described in AS 7664.

8 Turnouts

8.1 General principle

Light rail turnouts are used to divert LRVs from one track to another. The direction that the LRV travels is dependent on the positioning of the point blades.

Turnouts should not be located:

(a) at places in the street where there are concentrations of pedestrians, such as at identified pedestrian crossings and zones;

(b) where there would be a danger to cyclists or motorcyclists;

(c) in busy traffic, or where traffic lanes cross or merge with a tram lane, particularly where this is also aggravated by a turning movement;

(d) at traffic crossings where they are difficult to maintain; or

(e) in curved track sections.

For clarity, the term turnout refers to the whole system (including frogs and check rails) whereas the term point refers specifically to the mechanism which permits the change of path for an LRV. Further detail is provided in the RISSB Glossary.

8.2 Point operation

8.2.1 Manual operation

Manually operated points may be set by a competent worker using a points bar or a points lever.

Spring points may be used to allow an LRV to trail through the point without manual or powered movement of the point blades, with the point returning to the original position (usually straight position) after passage of the LRV.

Spring toggle or throw over points are held in the last trailed position after passage of the LRV.

Manually operated points should not be used on running lines for movements in the normal direction, unless the maximum permitted speed traversing the points is less than 15 km/h.

8.2.2 Power operation

Power operated points can be operated by a command from an approaching LRV (through transponders and transceivers), from a remote-control centre or dedicated local or yard management system.

Power operated facing points shall have a system of point locking fitted.

Point detection should be used to prove the point lock position.

Point locking may be electrical or mechanical.

Point locking shall be engaged when the:

(a) points are in the correct position;

(b) light rail signal is displaying a clear indication (where applicable);

(c) approaching LRV is within a minimum a defined distance from the point blade;

(d) LRV is traversing the points.

Detection systems as defined in section 7.7.3 may be used to assist in meeting the above requirements.

Where points are manually operated due to degraded operation (points fault) the power supply to the points shall be capable of disconnection by manual operation.

To allow for incorrect setting or changes in operational requirements point locking should be able to be disengaged provided the turnout is clear of any LRV.

Point control systems may permit stored routes. Stored routes shall not permit the point blades to move until the preceding LRV movement is confirmed as being clear of the turnout.

8.3 Turnout indicators

There are two types of turnout indicator:

(a) Manual turnout indicators (non-vital indication).

(b) Electric turnout indicators (vital indication).

Vital point indicators display right or left point position once the point blades are mechanically locked in the end position and no point lever is detected in the point machine socket.

Where non-vital point indicators are use an LRV driver shall visually check turnout position (speed <15km/hr) before proceeding.

Refer appendix E for standard point indications.

8.4 Interlocking

Electrically operated points in areas of light rail signalling shall be interlocked with the signalling system.

If the position of the points cannot be confirmed by the interlocking the applicable signal shall show a restricted aspect.

8.5 Prevention of collision at points

Where there is a risk of LRV collision at junctions or point locations light rail networks shall implement risk mitigation strategies to reduce that risk

Collision risks may be mitigated through:

(a) signal and point interlocking;

(b) preventing opposing movements through interlocking adjacent points (diverting opposing movements away from each other);

(c) signage;

(d) centralised network control of points;

(e) provision of visual aids, such as mirrors or closed-circuit television.

9 Operations

9.1 General

Light rail networks must develop policies, procedures, network control and driver manuals and training materials to safely manage operations in accordance with *Rail Safety National Law* as published in the applicable state or territory.

9.2 Failure situations

9.2.1 General requirements

Procedures shall be developed to permit operations under failures, degraded and emergency conditions of operation.

Procedures shall cover:

(a) LRV failure;

(b) traffic signal failure;

(c) light rail signal failure;

(d) points failure.

9.2.2 Light rail vehicle failure

Failure of an LRV can cause considerable interruption to light rail and road traffic.

Failure procedures should consider operation of multi-coupled LRVs with regards to:

(a) length of multi-coupled vehicles;
(b) passenger requirements;
(c) operational requirements.

10 Commissioning, maintenance, and decommissioning

10.1 General

The safety of an operating system depends on:

(a) correct equipment and system design to standards;
(b) correct manufacture to the design specifications;
(c) correct installation to the design and to standard practices; and
(d) correct maintenance to standards.

Light rail systems shall not be allowed to enter or re-enter service without first being subjected to suitable and sufficient testing to ensure safe operations.

10.2 Commissioning

Whilst excluded from AS 7717 light rail systems should, as far as reasonably practical, commission light rail signalling systems and points in accordance with that Standard.

Commissioning of new light rail systems shall assess and meet the requirements for TSC and other stakeholder systems.

10.3 Maintenance

The signalling system should be designed, so far as is reasonably practicable, to prevent the possibility of inadvertent errors during maintenance and repair work.

The signalling system should include recording and diagnostic systems for monitoring the health of the equipment and to enable appropriate investigation of any adverse incidents.

It should be possible for the maintenance and modification activities to be performed on equipment without undue risk to either the operational light rail system or the personnel carrying out the work. This can have implications for the design of equipment and its physical location.

10.4 Signals and indicators not in use

Light rail signals and indicators not in use should be clearly marked in accordance with the road and light rail network and safeworking rules.

Management of traffic signals not in use should be defined in accordance with the processes agreed with road manager.

10.5 Decommissioning

Where it has been identified that part or all of a light rail system is to be decommissioned or closed, all stakeholders shall be engaged to ensure that all requirements are identified and addressed so that the process can be safely managed.

Appendix A Hazard register

Informative

Hazard	Applicable clause
Collision between light rail vehicles	3.1, 3.2, 4.1
Collisions between light rail vehicles and other traffic (road vehicles, pedestrians, etc)	3.1, 3.2, 5.4, 5.5
Derailment	7.2, 7.3, 7.4
Security breaches, including cyber security	6.3
Impact on road traffic caused by light rail vehicle	4, 5, 6,
LRTAE	5.5, 6.6

Appendix B Design and human factors

Informative

B.1 Distraction

Driver distraction can occur at any time throughout a journey but is mainly a form of preoccupation with another task or an interruption to a routine. This can lead to a reversion or resumption of another routine, often a routine that is more familiar or often practiced (habit intrusion).

B.2 Signal positioning and indications

A driver's interpretation and response to signals and indicators can be influenced by expectation and mistaken context. This risk may be mitigated by uniform and consistent placement (location), and consistency and sequence of indications.

This extends to conflicts between signals and indicators where they are placed in close proximity to each other (in line of sight or opposite each other) but are used for different functions.

An incorrect driver response could be caused by inconsistent signal layouts, designs, and location. Therefore, the situation in which signals and indicators are presented to a driver is as important as signal sighting.

Further guidance can be found in AS 1742.14 and AS 7631

Appendix C Movement permission selection

Normative

The below table provides guidance as to what movement permission system should be used.

Type	Usage	Considerations
Road traffic signals	Crossings with road traffic signals	Conflicting indications with light rail signals could increase risk of LRTAE or collision with road and pedestrian traffic.
Light rail signals	Junctions Entry / exit at depots Assessed risk of collision	Conflicting indications with traffic signals could increase risk of LRTAE
Point indicators	Points where blade position cannot be confirmed from light rail vehicle cab Permitted speed over facing points above 15 km/h	Conflicting indications with traffic and light rail signals could increase risk of LRTAE

Appendix D Traffic and light rail signal indication types

Normative

The below indications shall be used to indicate movement permission to LRV drivers:

Indication	Indication meaning	Signal type
	Route set Arrow indicators may also be used to indicate direction	Traffic signal. May be used as a light rail signal.
	Route set, stop LRV at stop line if safely able to do so Arrow indicators may also be used to indicate direction	Traffic signal. May be used as a light rail signal.
	Route not set, stop LRV at stop line	Traffic signal. May be used as a light rail signal.
	Stop	Light rail signal
 or 	Call placed on Traffic System Controller to change to light rail phase.	Advance priority signal
	Points set to turn left Permission to move in accordance with Section 3	Light rail signal
	Points set to turn right Permission to move in accordance with Section 3	Light rail signal
	Points set straight Permission to move in accordance with Section 3	Light rail signal

Note: Standard (circular) road traffic signals also permitted in accordance with AS 1742.14

Appendix E Point indication types

Normative

The below indications should be used:

Indication	Indication meaning	Signal type
	Points set to turn left	Point indicator
	Points set to turn right	Point indicator
	Points set straight	Point indicator
	Points not set / locked	Point indicator

Appendix F Typical signal layout - terminal station

Informative

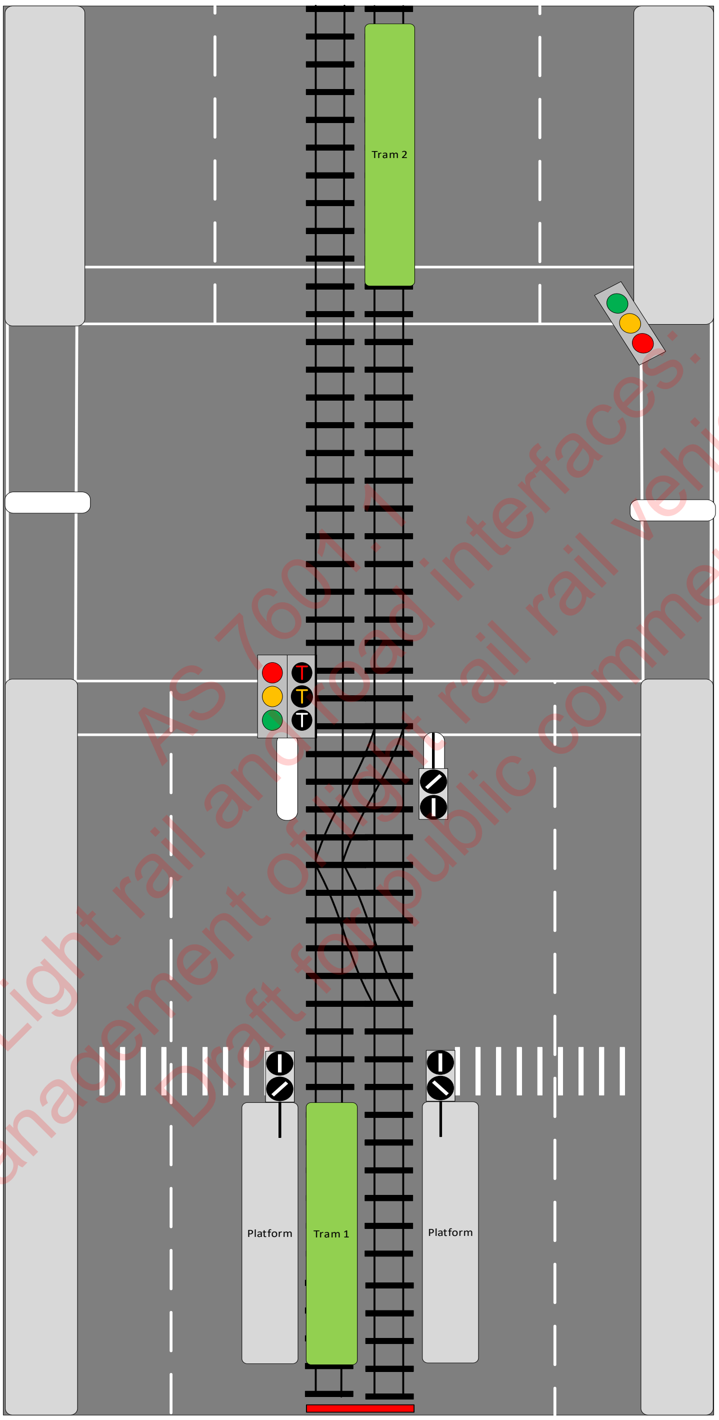

Diagram F:1.1 Terminal at intersection. Signal clusters used by road traffic only excluded for clarity.

Appendix G Phase priority zones

Informative

G.1 Detection point for phase priority

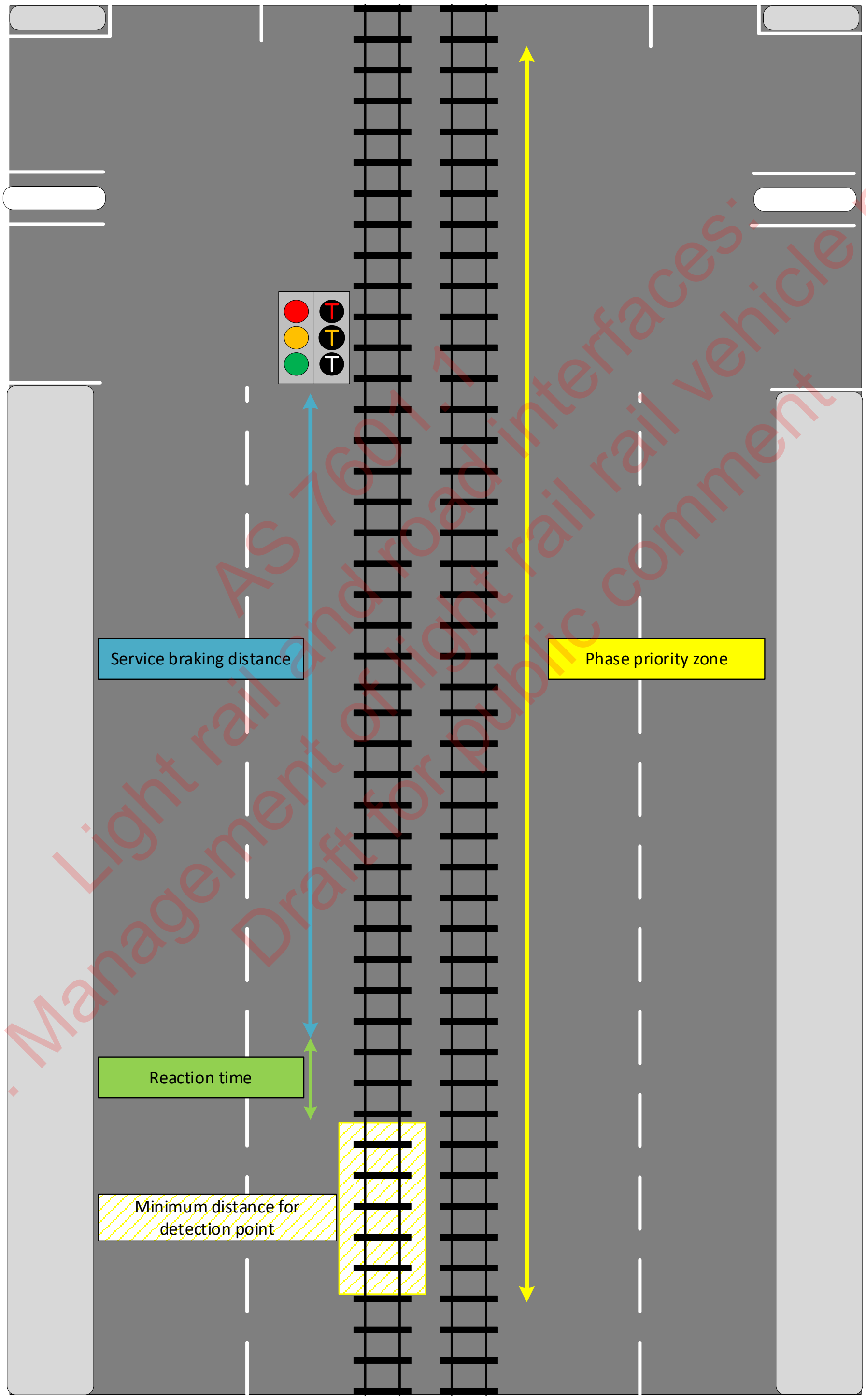

Diagram G:1.1 Minimum detection distance for phase priority

G.2 Detection point for advance phase priority

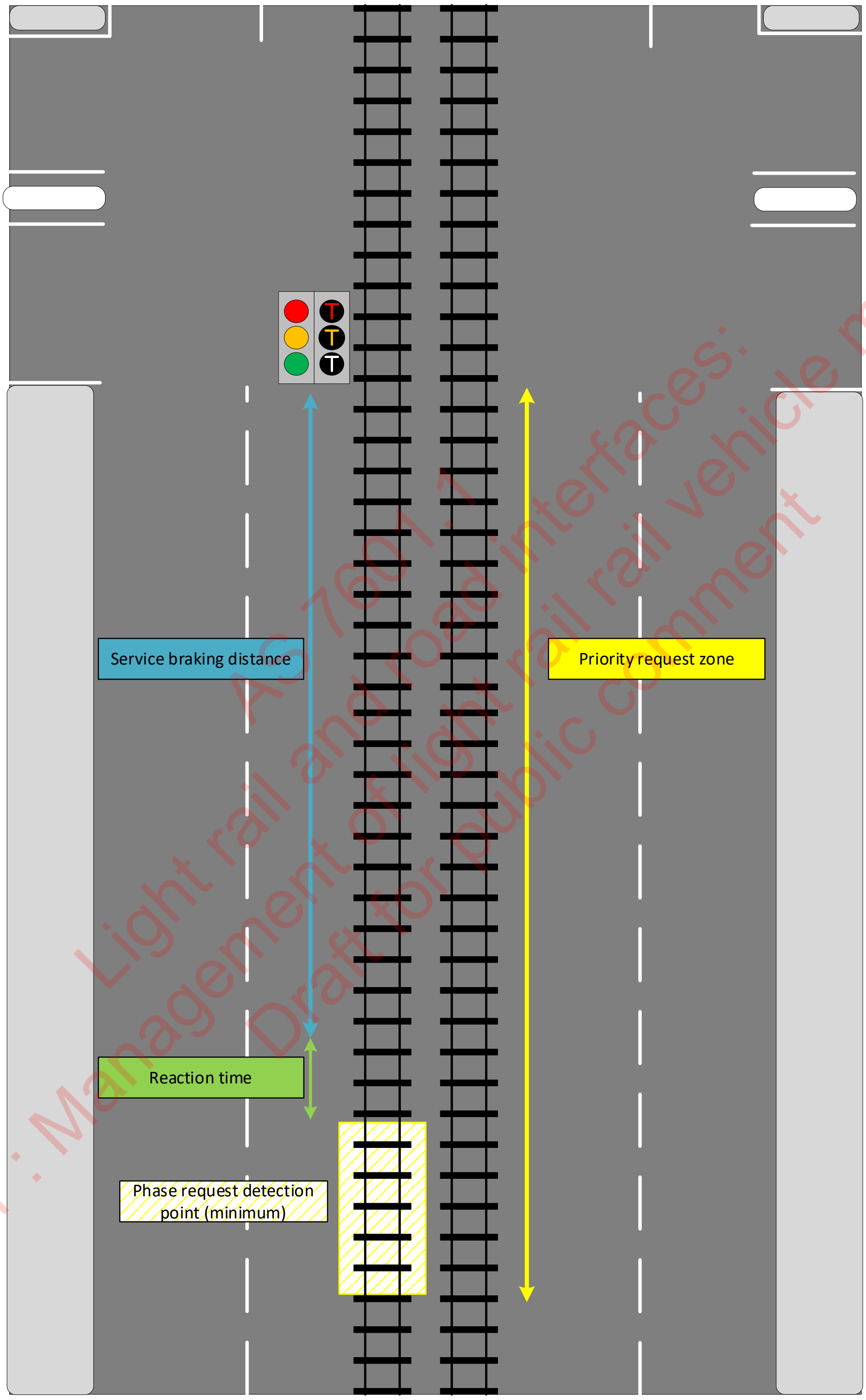

Diagram G:2.1 Minimum detection distance for advance phase priority

Appendix H Bibliography

The following referenced documents are used by this Standard for information only:

(a) AS 1742.2 Manual of uniform traffic control devices: Traffic control devices for general use

(b) AS 1742.12 Manual of uniform traffic control devices: Bus, transit, tram and truck lanes

(c) AS 7511 Train detection

(d) AS 7631 Railway infrastructure – sighting

(e) AS 7651 Axle counters

(f) AS 7717 Signal testing and commissioning

(g) AS 7770 Rail cyber security

(h) Code of Practice – Rail Cyber Security for Rolling Stock and Train Control Systems

(i) RISSB Guideline Management of Traffic with Unreliable Track Circuits

(j) *Rail Safety National Law 2012* (SA)

(k) Austroads - Guide to Traffic Management Part 9: Transport Control Systems – Strategies and Operations

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