Transport Asset Standards Authority

T LR SC 08001 ST

Standard

Rail Signalling Principles for Light Rail Networks

Version 4.0

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Standard governance

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Document history

Version	Summary of changes
1.0	First issue 17 May 2017.
2.0	Second issue 24 January 2018. Permit the use of non-locked facing points (such as spring operated points) where light rail vehicle approach speed is assured at 15 km/h or less and other conditions are met. Permit the use of specifically designed track circuits that forms part of a fit for purpose 'point controller system' which is used in the provision of approach-locking for facing points. Updated requirements for points detection and associated point indicator (or rail signal) for all points traversed in a facing direction. Clarification of intent for other requirements.
3.0	Third issue 20 January 2020. Updated RMS publications reference in Section 6.2 and Section 9.3. Added reference to Rolling Stock standards for risk considerations in Section 7.
4.0	Fourth issue – Updated to improve clarification of requirements and align rail signal indications with CSELR as recommended by PLR. The changes to this version include the following: • Clarified requirements for the following: o rail signalling o light rail vehicle detection o integrity of facing points o point detection o traffic intersections located along segregated alignments o point indicators o rail signals • Changed point indicator aspect (indications) to show 'red horizontal' when point detection is unknown • Recommended provision of signage for movement authority-limits • Changed rail signal aspect (indications) to be consistent with CSELR • Deleted repeated text in Section 9.2.5 where it stated that the rail signal or point indicator would display in correspondence with the points during manual operation (appropriately stated in Section 9.2.4)

Preface

The Asset Standards Authority (ASA) is a key strategic branch of Transport for NSW (TfNSW). As the network design and standards authority for NSW Transport Assets, as specified in the *ASA Charter*, the ASA identifies, selects, develops, publishes, maintains and controls a suite of requirements documents on behalf of TfNSW, the asset owner.

The ASA deploys TfNSW requirements for asset and safety assurance by creating and managing TfNSW's governance models, documents and processes. To achieve this, the ASA focuses on four primary tasks:

- publishing and managing TfNSW's process and requirements documents including TfNSW plans, standards, manuals and guides
- deploying TfNSW's Authorised Engineering Organisation (AEO) framework
- continuously improving TfNSW's Asset Management Framework
- collaborating with the Transport cluster and industry through open engagement

The AEO framework authorises engineering organisations to supply and provide asset related products and services to TfNSW. It works to assure the safety, quality and fitness for purpose of those products and services over the asset's whole-of-life. AEOs are expected to demonstrate how they have applied the requirements of ASA documents, including TfNSW plans, standards and guides, when delivering assets and related services for TfNSW.

Compliance with ASA requirements by itself is not sufficient to ensure satisfactory outcomes for NSW Transport Assets. The ASA expects that professional judgement be used by competent personnel when using ASA requirements to produce those outcomes.

About this document

This document specifies the rail signalling principles for light rail networks. It provides the high-level framework, principles and fundamentals for rail signalling within light rail networks governed by Transport for NSW.

This is a fourth issue.

The changes to previous content include the following:

- Clarified requirements for the following:
    - rail signalling
    - light rail vehicle detection
    - integrity of facing points
    - point detection
    - traffic intersections located along segregated alignments

  - point indicators
  - rail signals

- Changed point indicator aspect (indications) to show ‘red horizontal’ when point detection is unknown.
- Recommended provision of signage for movement authority-limits.
- Changed rail signal aspect (indications) to be consistent with CSELR.
- Deleted repeated text in Section 9.2.5 where it stated the rail signal or point indicator would display in correspondence with the points during manual operation (appropriately stated in Section 9.2.4).

Table of contents

1. Introduction

As planning and construction of Transport for NSW (TfNSW) light rail networks increases, the need for relevant engineering standards is of paramount importance. Effective light rail engineering standards ensure that the desired levels of consistency, interoperability, interface management, and reliability, availability, maintainability and safety (RAMS) are achieved for the light rail systems' whole-of-asset life.

2. Purpose

This standard sets the minimum requirements to be applied to TfNSW light rail networks to ensure safe movements of light rail vehicles within the identified alignment types.

2.1. Scope

This standard outlines the principles and fundamental requirements for rail signalling within the TfNSW light rail networks.

Though this document makes references to traffic signalling, this document does not cover the requirements for traffic signalling.

2.2. Application

This standard applies to the rail signalling components of TfNSW light rail networks.

3. Reference documents

The following documents are cited in the text. For dated references, only the cited edition applies. For undated references, the latest edition of the referenced document applies.

Australian standards

AS 1742.7:2016 Manual of uniform traffic control devices – Part 7: Railway crossings

AS 1742.14:2014 Manual of uniform traffic control devices – Part 14: Traffic signals

AS 4292.1 Railway safety management – Part 1: General requirements

AS 4292.4 Railway safety management – Part 4: Signalling and telecommunications systems and equipment

Transport for NSW standards

RMS Traffic signal design guidelines

T LR CI 12510 ST Civil Requirements for Alignment Configuration

T LR RS 00200 ST LRU 200 Series – Minimum Operating Standards for Light Rail Vehicles – Common Interface Requirements

T MU CY 10503 GU AEO Guide to Engineering Competence Management

Legislation

Rail Safety National Law (NSW)

4. Terms and definitions

The following terms and definitions apply in this document:

active transport user pedestrians, cyclists, scooter and wheel chair users, and so on

AVLS automatic vehicle location system

CRS Centre for Road Safety

EMC electromagnetic compatibility

facing points those points with the switch blades facing approaching rail traffic

GPS global positioning system

NetOps TfNSW Network Operations (SCATS)

OCC operations control centre

pedestrian crossing used within the context of this document, an at-grade crossing located along light rail segregated alignments provided for the exclusive use of active transport users; it excludes the crossing of road vehicles

PID passenger information display

RMS Roads and Maritime Services

running lines those lines used for the through movement of rail traffic

SCATS Sydney coordinated adaptive traffic system

SFAIRP so far as is reasonably practicable

SIL safety integrity level

TfNSW Transport for NSW

TMC Transport Management Centre

5. Light rail signalling high-level concepts and principles

The high-level concepts set the context to the principles and fundamental requirements in this standard. These concepts have been sourced from various standards, as referenced throughout this document and additionally developed in consultation with Roads and Maritime Services (RMS).

The requirements stated in this standard align with the following high-level principles set by TfNSW:

- consistency of user interfaces
- standardisation, where there is a demonstrable benefit to TfNSW
- addressing safety issues relating to the rail signalling component of light rail systems
- interoperability between networks

6. Light rail vehicle movement authority modes

A movement authority is the authorisation given to a light rail vehicle to proceed.

The movement authority modes applicable to TfNSW light rail networks are as follows:

- line of sight
- traffic signalling
- rail signalling

Figure 1 illustrates an indicative view of the light rail movement authority modes.

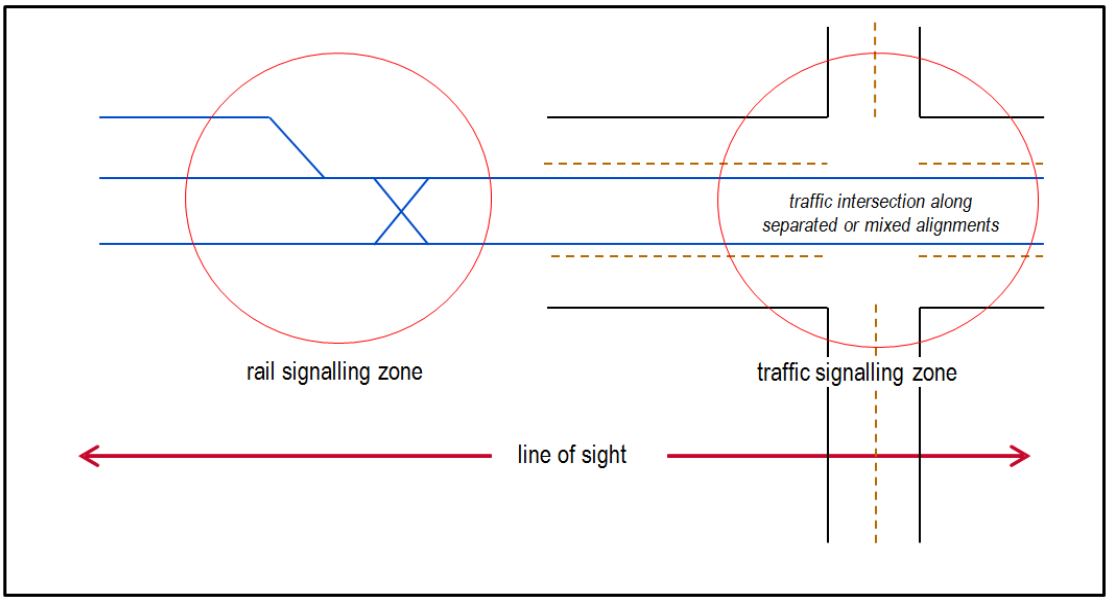


Figure 1 – An indicative view of the light rail movement authority modes

6.1. Line of sight

Line of sight shall be deployed as the primary movement authority mode.

In this mode, the light rail vehicle driver is responsible for maintaining, in all circumstances, a safe distance from any preceding light rail vehicle, as well as any road vehicle or active transport user in respect to service-braking capability. The light rail vehicle driver ascertains the occupancy rights for the track section ahead and the general clearance of gauge.

In the line of sight mode, the light rail vehicle driver adapts the speed of the vehicle according to designated speed limits and warning signs as provided, so as to ensure safe movement of the vehicle.

The driver also takes into account variable situational risks, such as increased traffic (including active transport users) and any prevailing conditions that can deteriorate ideal sighting and braking performance. The driver subsequently controls the vehicle accordingly, so as to stop the vehicle safely before any obstruction or other hazard.

Additionally, the light rail vehicle driver observes traffic signalling and rail signalling applicable to the alignment, and ensures effective control of the vehicle in order to stop before any relevant signal that is displaying a stop-aspect.

6.2. Traffic signalling

The signalling governed by the responsible road entities, such as RMS and Centre for Road Safety (CRS) is referred to in this standard as ‘traffic signalling’.

Where a light rail vehicle requires protection in separated or mixed alignments from other traffic (such as road vehicles and active transport users), or otherwise where a light rail vehicle can cause risk to road vehicles and active transport users, then the protection of such hazards shall be governed by traffic signalling.

Refer to the applicable RMS *Traffic signal design* guidelines and Austroads publications for requirements.

6.3. Rail signalling

Rail signalling is used where warranted by a risk assessment, to provide protection for light rail vehicles from collision with other light rail vehicles, and to protect against derailment. Rail signalling also governs the protection for all users at traffic intersections located along segregated alignments.

Furthermore, rail signalling can be used for enabling efficient shunting movements of light rail vehicles.

Rail signalling, through the provision of signalled routes, can manage such situations as the following:

- occupancy rights for the track section ahead
- clearance of gauge at points
- operation and integrity of facing points within the route
- trailability of points within the route
- flank protection and overrun protection
- traffic intersections located along segregated alignments

6.4. Considerations when determining movement authority modes

The determination of an intended movement authority for a given section of track shall be supported by a risk assessment to justify the mode chosen. This assessment shall include the proposed design solutions that will control the identified hazards.

When in line of sight mode, the vehicle speed is the primary control method to manage hazards. When assessing the suitability of line of sight, factors such as sighting time, reaction time and ability of light rail vehicles to stop (for example, when descending steep gradients) shall be taken into account.

The movement authority of a light rail vehicle may be issued exclusively by any mode or a combination thereof.

6.5. Traffic intersection management

Proper management is required for the safe and efficient movement of all traffic (including light rail vehicles) at traffic intersections and other shared spaces along the light rail corridor.

For light rail vehicle movements, the light rail vehicle driver at a traffic intersection shall obtain all the required assurances before proceeding.

These assurances are typically provided by the following means (depending on location and situation):

- line of sight
- T-light signal
- point indicator or rail signal (where applicable)

For example, a white T-light signal alone may be insufficient authority for the light rail vehicle to proceed across a traffic intersection that is co-located with a track junction; additionally other authorisations are typically needed.

These include ascertaining the occupancy rights for the track section ahead, which is established by the line of sight mode and an assurance that the facing points are safe to traverse, which is obtained from the point indicator or rail signal.

Where T-light signals and point indicators or rail signals coexist, it is imperative that the intent and indication of each signal is explicit and as such, is cross-checked against all associated risk controls.

6.5.1. Intersection prioritisation

Prioritisation at traffic intersections is a key aspect of traffic management. When using modelling tools to assist in determining intersection prioritisation for services, the designer shall include an assessment of operational impacts to all users of the traffic intersection.

Where rail signalled routes have the capacity to cause a delay to traffic controller cycle times, it may be necessary to provide an input to the traffic controller of such intended route prior to its actual commencement. This can assist with prioritisation of traffic signals for light rail vehicles.

The intersection prioritisation determination shall apply an overall balance of operation that achieves the best outcome for all intersection users.

6.6. Special running

Where light rail vehicle movement authorities are managed using an operating procedure, such as when in degraded mode, all relevant risks shall be suitably managed in accordance with the intentions of these rail signalling principles.

Relevant safety regulatory bodies shall be satisfied that the proposed procedures reduce the risks to a safe level that is so far as is reasonably practicable (SFAIRP). The operating procedure shall also satisfy the requirements of the *Rail Safety National Law (NSW)*, as imposed by the rail regulator.

Note: These requirements are additional to any road laws imposed by RMS and CRS.

7. Risk considerations

The hazards and risks associated with the operation of light rail vehicles over a light rail network are generally different from those pertaining to heavy rail. In a heavy rail network, rail vehicles operate in stringently controlled conditions. Conversely, the light rail environment exposes light rail vehicles to varying conditions, including open and shared spaces, where road vehicles and active transport users can come in close proximity to moving light rail vehicles.

The accountability for risk assessments and subsequent mitigations shall be borne by the appropriate entities that hold the relevant expertise and responsibility.

The risks surrounding the operation of light rail vehicles can differ across the various alignment types (segregated, separated or mixed). Therefore, any proposed risk control intended for one alignment type shall take into account the other alignment types to ensure that they do not impose adverse impacts.

> *Note: Definition of alignment types applicable to TfNSW light rail networks are provided in T LR CI 12510 ST Civil Requirements for Alignment Configuration.*

Additionally, the wider impact of controls shall be taken into account when conducting risk assessments. Any adverse impacts imposed on other users (adjacent or within an alignment's shared space) shall be eliminated or minimised to a safe level that is SFAIRP.

For further information regarding risk controls associated with driver safety systems (such as for over-speed protection, driver vigilance, driver awareness, and so on) refer to T LR RS 00200 ST *LRU 200 Series – Minimum Operating Standards for Light Rail Vehicles – Common Interface Requirements.*

7.1. Key risks

Key risks that can be mitigated by rail signalling design are identified to ensure that they are considered and adequately addressed.

> *Note: While these risks are considered here for context to the standard, they are also intended to form part of a more comprehensive risk assessment developed in the design phase of rail signalling requirements.*

The following is a list of key risks typical of a light rail network:

- collision between converging, diverging, opposing or preceding light rail vehicles
- collision with road vehicles and active transport users
- derailment at points
- derailment caused by over-speed
- runaway of light rail vehicle leading to derailment or collision
- security breaches of operating equipment, including cybersecurity
- loss of light rail vehicle location (whereabouts) affecting the operations control centre (OCC) and passenger information displays (PID)
- impact on traffic congestion caused by light rail vehicles (for example, light rail vehicle prioritisation or presence)

8. Light rail signalling principles

The principles stated in Section 8.1 through to Section 8.4 apply to the rail signalling requirements for light rail vehicle movements. They are primarily applied to running lines, and to adjacent lines where they can impact the safety of running lines. They shall form the basis of the rail signalling design.

8.1. Basic signalling principles

The following is a list of basic rail signalling principles:

- the simplest effective means of signalling shall be deployed for the movement of light rail vehicles
- explicit and consistent information shall be provided to enable the light rail vehicle driver to control the vehicle safely
- where rail signalling is used, the protection for a route for which a movement authority has been issued shall remain until it has been traversed, or until the light rail vehicle has stopped and will no longer use the route
- fail-safe functionality, such that any predictable type of failure of an item of signalling equipment leads to a more rather than less restrictive operating condition
- the safety integrity level (SIL) rating of equipment used for rail signalling shall be commensurate with the safety levels expected of such systems; this determination shall be made by a risk assessment during the design phase
- rail signalling work shall be managed and performed to meet the requirements of the following:
    - AS 4292.1 *Railway safety management – Part 1: General requirements*
    - AS 4292.4 *Railway safety management – Part 4: Signalling and telecommunications systems and equipment*
    - *Rail Safety National Law (NSW)*

8.2. Principles for movement authority

The following is a list of principles applicable to movement authority:

- line of sight shall be the primary mode of operation where sufficient sighting distance and appropriate speed limits permit the light rail vehicle driver to stop the vehicle safely, using only the service brake

- rail signalling shall be used as the movement authority in locations where line of sight provides inappropriate or insufficient risk mitigation; this shall be determined by a risk assessment
- traffic signals applicable to light rail vehicles shall be observed independently of any rail signal or line of sight; that is, the movement authority for a light rail vehicle shall require the permissive state of each mode, as applicable
- point indicators shall be provided on approach to facing points where rail signals are not used to assure the integrity and direction set by the facing points

  Note: Point indicators do not provide the sole means of a movement authority.

8.3. Principles for facing points

The following is a list of principles applicable to facing points:

- approach-locking of facing points shall be provided to prevent the power operation of points once an approaching light rail vehicle is within service-braking distance of the facing end
- the switch rails of facing points shall be positively held in their correct positions, and prevented from moving by physical means (locked); this condition shall remain effective until the light rail vehicle has completely cleared the points

  Note: An exemption for the facing point lock requirement is permitted in accordance with this standard (see Section 9.2.2).
- facing points shall be detected for correct switch rail positions, and locking effectiveness (where applicable)

8.4. Principles for traffic intersections located along segregated alignments

The following is a list of principles applicable to designated traffic intersections located along segregated alignments:

- at road intersections, a combination of active and passive controls shall be provided to protect all users of the intersection, including approaching light rail vehicles
- at pedestrian crossings where road vehicles are not involved, passive controls only may be provided in lieu of active and passive controls if determined by a risk assessment to be sufficient mitigation

9. Light rail signalling fundamental requirements

9.1. Light rail vehicle positioning

A means to detect the position of light rail vehicles shall be deployed to meet the objectives of light rail vehicle positioning. The following two levels apply to light rail vehicle positioning:

- light rail vehicle detection
- light rail vehicle location (whereabouts)

The determination to which level of light rail vehicle positioning is appropriate shall be done at the stage of planning and feasibility for the initial design and concept of operations. This shall be done in conjunction with a risk assessment for the associated rail signalling.

9.1.1. Light rail vehicle detection

Where the position of a light rail vehicle warrants the provision of a safe condition, then this concept shall be known as 'light rail vehicle detection'.

Light rail vehicle detection shall be an input into the rail signalling interlocking (controller) for the management of safe elements pertaining to rail signalling (where used), such as the following:

- light rail vehicle conflict
- approach-locking of facing points
- occupancy rights for the track section ahead
- clearance of gauge at points

The SIL rating of the light rail vehicle detection system shall be commensurate with the safety levels expected. This shall be determined by a risk assessment.

Track circuits

Track circuits shall not be used for the purpose of light rail vehicle detection.

This exclusion is due to its reliance on an effective wheel-to-rail interface which may not be suitable for relatively light-weight rail vehicles. Difficulties sustaining an effective (clean) rail contact-band can also be experienced, especially in mixed alignments and seldom used areas (such as stabling and maintenance facilities).

Notwithstanding the aforementioned requirement, the use of specifically designed track circuits that forms part of a fit for purpose ‘point controller system’, which function in combination with other detection equipment (such as a command loop) to provide approach-locking of facing points is permitted. However, such permission shall be subject to all the associated risks being adequately treated to ensure that safety can be demonstrated to a level that is SFAIRP.

See Section 9.2.1 for further information on approach-locking of facing points.

Induction loops

Induction loops shall not be used for the purpose of light rail vehicle detection.

Notwithstanding the aforementioned requirement, induction loops may be used in rail signalling to initiate a permissive traffic signal sequence in favour of the approaching light rail vehicle at traffic intersections located along segregated alignments.

The induction loops shall work in conjunction with T-light signals provided on the rail approaches to the intersection.

See Section 9.3 for further information on controls for traffic intersections located along segregated alignments.

9.1.2. Light rail vehicle location

Where the position of a light rail vehicle warrants only its whereabouts information, and the safety requirements are not stringent, then this concept shall be known as 'light rail vehicle location'.

Light rail vehicle location systems, such as automatic vehicle location system (AVLS) shall provide only non-safety related inputs for use in systems, such as the OCC and PID systems.

9.2. Points

Points provide the means of diverting light rail vehicles from one track to another, such as at junctions, crossovers and turnouts. The requirements for safe operation and the mitigation of risks associated with light rail vehicle movements through points shall be managed to achieve a safe level that is SFAIRP.

For the purpose of this standard, facing points are those point ends traversed in a facing direction that are located on running lines, and on adjacent lines where they can impact the safety of running lines.

Section 9.2.1 through to Section 9.2.6 provide the minimum requirements for facing points.

9.2.1. Approach-locking of facing points

Approach-locking of facing points shall be provided to prevent the power operation of points once an approaching light rail vehicle is within service-braking distance of the facing end. The approach-locking shall only be released once the light rail vehicle is proven to be stationary before the facing end, or otherwise has completely cleared the points.

Approach-locking of facing points may utilise specifically designed track circuits that form part of a fit for purpose ‘point controller system’, which function in combination with other detection equipment (such as a command loop).

The combination of equipment shall necessitate the proving of both means of detection to establish the approach, and clearance status of a light rail vehicle in respect to the facing end.

The use of this type of vehicle detection, for the purpose of approach-locking shall be conditional of all risks being adequately treated to ensure a demonstrably safe level that is SFAIRP.

9.2.2. Integrity of facing points

The switch rails of facing points shall be positively held by physical means, such that both the closed-switch and open-switch remain in their correct positions until the light rail vehicle has completely cleared the facing end.

The switch rails of facing points shall be prevented from moving (locked) while a light rail vehicle is traversing the points. The locking shall be achieved by physical means and remain effective until the light rail vehicle has completely cleared the points.

The ‘facing point lock’ requirement may be exempt where all the following conditional requirements are met:

- a light rail vehicle’s speed is assured to not exceed 15 km/h when approaching the facing end (level of assurance provision determined by risk assessment)
- the mechanism used to operate the point switch rails is purpose-designed, so it positively holds the switch rails with sufficient force irrespective of whether the points are biased manually or by spring tension
- the open-switch rail of points (where applicable) is held in the correct open-position using the same operating forces applied to the closed-switch rail
- the forces that apply the facing point integrity shall not impede the capability for achieving point trailability (achieved without damage to the equipment)
- the points equipment that apply positive forces to the switch rails, shall have adequate engineering to mitigate the case of single mode failure
- the total length of light rail vehicle entering facing points, which are not fitted with a facing point lock shall not exceed 67 m (applies only while operating in normal mode)
- the decision to install facing points without a facing point lock has been determined by risk assessment to be at a safe level that is SFAIRP
- the residual risk profile has met the business requirements expected by TfNSW

9.2.3. Point detection

Point detection shall prove the positions of switch rails (closed-switch and open-switch) of facing points. The detection shall be made only when the switch rails are in their correct positions. The detection shall be applicable to the position of points intended for travel in a facing direction.

Where facing point locks are used, the point detection shall also detect the position of the lock such that it proves the effectiveness of the lock.

Point detection shall be an input into the rail signalling interlocking (controller). The detection output shall govern the associated rail signal or point indicator aspect. Point detection may be configured as a local arrangement where point indicators are used outside of an interlocking area (no rail signals).

In any case, the point detection shall be indicated at the OCC.

9.2.4. Manual operation of power-worked points

Where power-worked points are used, they shall be provided with a means for manual operation, to be used when in degraded mode.

Power control to the point mechanism shall be cut-out while the points are being operated in manual mode.

Where the associated rail signal or point indicator is in working order, then it shall continue to display the correct aspect in correspondence with the points, while the manual operation is in use.

9.2.5. Location and security of points equipment

Point switch rails and related operating equipment shall preferably be located to minimise the risk to pedestrians, as well as maintainers. Where this situation cannot be avoided, the equipment shall be suitably designed to a safe level that is SFAIRP.

Point switch rails located in the road space shall be suitably designed to mechanically withstand the associated loading.

9.2.6. Points located within a traffic intersection

Where a traffic intersection includes a facing point junction, the associated rail signal or point indicator shall be installed in a position that is commensurate with the associated intersection T-light signal so as to avoid confusion for the light rail vehicle driver.

The illumination of the white T-light signal shall be conditional on the points' integrity being set in correct position. The point detection shall be provided as a separate input to the road traffic controller. A white T-light signal shall not be indicated until the point switch rails are detected to be in correct position, and the facing point lock engaged (where mandated).

Where these conditions are not able to be met, a degraded mode of operation shall be implemented.

Point detection at these junctions shall also be indicated to the light rail vehicle driver as described in Section 9.4.2 and Section 9.4.3.

9.3. Traffic intersections located along segregated alignments

For the purpose of this standard, all at-grade level crossings shall be termed 'traffic intersections'.

The three traffic intersection types that cross light rail segregated alignments (which are governed by rail signalling standards) are as follows:

- road intersections with active and passive protection
- pedestrian crossings with active and passive protection
- pedestrian crossings with passive protection

Road intersections are those located along light rail segregated alignments provided for the shared use of road vehicles and active transport users.

Pedestrian crossings are those located along light rail segregated alignments provided for the exclusive use of active transport users; they exclude the crossing of road vehicles.

> *Note: Traffic intersections located along separated or mixed alignments are part of the traffic signalling zone. Refer to the applicable RMS Traffic signal design guidelines and Austroads publications for requirements.*

9.3.1. Road intersections located along segregated alignments

Designated road intersections located along segregated alignments shall be protected by active and passive controls, including signals, signs and markings. Audible warning for active transport users that also cross at these road intersections may be provided where warranted. This determination shall be made by a risk assessment.

Road intersections located along segregated alignments shall be treated in accordance with the minimum requirement stated in Clause 2.3.9 of AS 1742.7: 2016 *Manual of uniform traffic control devices – Part 7: Railway crossings* and the RMS *Traffic signal design* guidelines.

All users requiring entry through these intersections shall have a proceed-aspect displayed for their movement. T-light signals shall be provided for the light rail vehicle.

The approaching light rail vehicle shall have a stop-aspect (red T-light) displayed until such time that a successful stop-aspect for the road user is displayed. When this condition is met, a proceed-aspect (white T-light) can be displayed to the light rail vehicle.

Signal indications used at these road intersections shall be consistent with the applicable requirements stated in AS 1742.14: 2014 *Manual of uniform traffic control devices – Part 14: Traffic signals* and the RMS *Traffic signal design* guidelines.

The road intersection control equipment shall have a SIL rating appropriate to control the identified risks.

The intersection prioritisation shall be determined by TfNSW. However, the intersection's normal state (without any light rail vehicle approaching) shall be biased towards the road approaches.

Suitable signage warning the light rail vehicle driver of an approaching road intersection shall be provided, and positioned at sufficient distance from the associated intersection.

Notwithstanding the aforementioned requirements, the signals, signs and markings provided at these road intersections shall have a common look to the user, similar to the signals, signs and markings used at other road intersections.

9.3.2. Pedestrian crossings located along segregated alignments

Designated pedestrian crossings located along segregated alignments shall have either passive controls only or a combination of active and passive controls to protect the crossing traffic. The decision to use either method of protection shall be determined by a risk assessment.

Suitable signage to warn the light rail vehicle driver of an approaching pedestrian crossing shall be provided, and positioned at a sufficient distance from the crossing.

Notwithstanding the requirements herewith, the signals, signs and markings (as applicable) provided at these pedestrian crossings shall have a common look to the user that is similar to the signals, signs and markings used at other pedestrian crossings.

Passive controls

Passive controls are static measures that mitigate crossing risks that do not require activation by the light rail vehicle as it approaches the pedestrian crossing. These controls can range from advisory to more positive controls that influence the behaviour of the user prior to crossing. Some examples of these measures include warning signs, marked pathways, barriers and chicanes.

The most effective of these controls are those that both impede the progress of the user and alert the user before they cross the track.

Active controls

Active controls are those that require activation by the approaching light rail vehicle to perform their prescribed function. They shall be used in conjunction with passive controls where the use of passive controls only provides insufficient risk mitigation for the pedestrian crossing.

Active controls typically consist of pedestrian crossing lights (including cyclist crossing lights and other such lights as required) and audible alarms where warranted.

All users requiring entry through these intersections shall have a proceed-aspect displayed for their movement. T-light signals shall be provided for the light rail vehicle.

The approaching light rail vehicle shall have a stop-aspect (red T-light) displayed until such time that a successful stop-aspect for the active transport user is displayed. When this condition is met, a proceed-aspect (white T-light) can be displayed to the light rail vehicle.

Signal indications used at these intersections shall be consistent with the applicable requirements stated in AS 1742.14: 2014 and the RMS *Traffic signal design* guidelines.

The active pedestrian crossing control equipment shall have a SIL rating appropriate to control the identified risks.

The intersection prioritisation shall be determined by TfNSW. However, the intersection's normal state (without any light rail vehicle approaching) shall be biased towards the active transport approaches.

9.4. Signal indications used in light rail

Signal indications shall give the light rail vehicle driver a consistent and unambiguous communication regarding the safe passage of their vehicle.

Signal indications shall communicate the status of hazards, such as at facing points, traffic intersections, occupancy rights for the track section ahead, clearance of gauge at points, and other purposes where a risk assessment identifies mitigation from the use of signals.

Signal indications shall give the light rail vehicle driver a proceed-aspect or stop-aspect depending on the condition of the identified risk.

The positioning and focusing of each signal shall be taken into account to provide the best sighting for its intended user and also to ensure that any chance of misreading is reduced to a safe level that is SFAIRP.

The number of signals (including rail signals, point indicators and traffic signals) to be observed by a light rail vehicle driver at any one location shall be minimised to avoid possible confusion.

9.4.1. T-light signal (traffic signal)

T-light signal indications for a light rail network shall display a red T-light, a yellow T-light (as required) and a white T-light in accordance with AS 1742.14: 2014, the RMS *Traffic signal design* guidelines and any other requirements as set by RMS and CRS.

The definition of each indication is described in Section 2.6.2 of AS 1742.14:2014 and RMS *Traffic signal design* guidelines.

9.4.2. Point indicators

Point indicators shall be provided to inform light rail vehicle drivers of the status of facing points located on running lines, and on adjacent lines where they can impact the safety of running lines.

The point indicator itself does not authorise a movement; rather it provides an assurance of the integrity and direction set by the facing points so as to enable a determination whether the points are safe to traverse. A movement authority in this case is further provided by the line of sight or white T-light signal, or both. See Section 6 for information on movement authority modes.

Point indicators shall not be used where the movement authority through the facing points is governed by a rail signal. In this case, the rail signal shall include the detection of the facing points within the route.

A point indicator directional-aspect shall be displayed when the associated facing point switch rails are in their correct position and where mandated, are physically locked for the facing-direction move. The directional-aspect shall correspond with the direction of travel set by the facing points. A point indicator stop-aspect shall be displayed when the associated facing points detection is unknown (detection not made).

Where a track junction is co-located within a road intersection, the point indicator shall function independently of the T-light signal. However, the illumination of an associated white T-light signal shall be conditional upon the point detection being made to the traffic controller. See Section 9.2.6 for further information.

The point indicator shall be positioned such that the display is not ambiguous to the light rail vehicle driver.

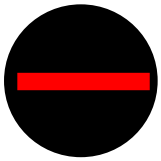
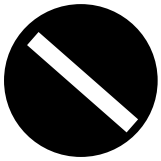
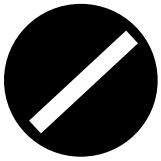
Point indicator aspects

The point indicator stop-aspect shall take the form of a red illuminated bar against a black background.

The point indicator directional-aspects shall take the form of a white illuminated bar against a black background.

Table 1 describes the aspects that apply to the point indicator.

Table 1 – Point indicator aspects

Aspect	Meaning
Red illuminated bar at horizontal 	Stop – points detection unknown (detection not made)
White illuminated bar inclined at 45 degrees to the left 	Right hand switch rail closed
White illuminated bar inclined at 45 degrees to the right 	Left hand switch rail closed

Note: The white inclined aspects featured on point indicators are intended to distinguish them from rail signals which have yellow inclined aspects.

9.4.3. Rail signals

Rail signals shall be used where a risk assessment has identified the line of sight mode and traffic signals alone to be inappropriate or insufficient. Where rail signals are used to manage light rail vehicle movements, this shall be known as a 'rail signalling zone'.

Note: Traffic signals, in accordance with Section 9.4.1 are used to provide the protection for users (including light rail vehicles) at traffic intersections. Rail signals are not used for this purpose. See Section 9.3 for more information.

The rail signal provides a movement authority to the light rail vehicle driver for a specified section of track. A proceed-aspect shall only be displayed once all the rail risks are controlled; that being the rail hazards within the route, designed for mitigation are safe and secure. The movement authority shall take into account the occupancy rights for the track section ahead, the clearance of gauge at points as well as the detection of facing points within the route.

A stop-aspect shall be displayed when the route has not been set or the rail hazards, designed for mitigation are not safe and secure.

Where the movement authority-limits of rail signalling are unclear, the provision of suitable signage should be considered so as to advise the light rail vehicle driver of such limits. This forewarns that the line of sight will succeed rail signalling as the mode governing the occupancy rights for the track section ahead.

Where a track junction is co-located within a road intersection, the rail signal shall function independently of the T-light signal. However, the illumination of an associated white T-light signal shall be conditional upon the point detection being made to the traffic controller. See Section 9.2.6 for further information.

The rail signal shall be positioned such that the display is not ambiguous to the light rail vehicle driver.

Rail signal aspects

A rail signal stop-aspect shall take the form of a red illuminated bar against a black background.

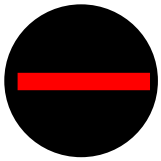
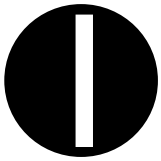
A rail signal proceed-aspect for the straight-ahead movement shall take the form of a white illuminated bar against a black background.

A rail signal proceed-aspect for the directional movements shall take the form of a yellow illuminated bar against a black background.

Where multiple routes are authorised by a rail signal, an alphanumeric indicator may accompany the rail signal aspects.

Table 2 describes the aspects that apply to the rail signal.

Table 2 – Rail signal aspects

Aspects	Meaning
Red illuminated bar at horizontal 	Stop - no movement authority
White illuminated bar at vertical 	Proceed - straight ahead movement
Yellow illuminated bar inclined at 45 degrees to the left 	Proceed - left direction movement
Yellow illuminated bar inclined at 45 degrees to the right 	Proceed - right direction movement

9.5. Competency and authorisations for rail signalling activities

Personnel working on light rail signalling equipment shall be deemed competent to perform their intended tasks. They shall hold current authorisation to perform such work for the individual network. This shall be done in accordance with AS 4292.1 and the *Rail Safety National Law (NSW)*.

Note: Guidance in relation to the development, implementation and maintenance of effective competency management systems can be sourced from T MU CY 10503 GU AEO Guide to Engineering Competence Management.

9.6. Equipment and system security

The integrity of light rail signalling equipment shall not be compromised by unintended access or vandalism. Measures shall be put in place to ensure its security.

Installations shall comply with the relevant standards relating to physical security and cybersecurity.

Consideration shall also be given to environmental conditions, and the associated impacts to the equipment and the environment when determining the physical location of such equipment.

10. Light rail signalling interfaces

The following stakeholders are identified as having key interfaces with light rail signalling for a light rail network:

- rolling stock
    - OCC
    - signalling compatibility
    - braking capability
    - electromagnetic compatibility (EMC)
    - vehicle overhang
    - vehicle length
    - kinematic envelope
    - onboard driver safety systems
    - driver visibility
- track and civil
    - point switch rails and related requirements
    - signalling compatibility
    - converging and diverging clearance locations (for flank protection)
    - structure gauge
    - line speed limits
    - track geometry and sighting distance
- electrical
    - OCC
    - EMC

  - traction supply and traction return
  - electrical power
  - combined service route
- stations and stops
  - OCC
  - stopping locations
  - pedestrian access
- technology and communications
  - OCC
  - transmission systems
  - voice and data communication for control system
  - light rail vehicles location systems, such as global positioning system (GPS)
  - combined service route
  - cybersecurity
- roads
  - OCC
  - TMC
  - NetOps
  - Sydney coordinated adaptive traffic system (SCATS) traffic signalling
  - signal sighting
  - ambiguous aspects
  - trackside signalling equipment placement and security (for example, points, signals, axle counters, command loops)
  - intersection prioritisation
  - light rail vehicle movement authority protocols, including degraded mode operation
  - light rail vehicle look-ahead information
  - transit way speed limits
  - road safety risk assessments