SAPTA

Government of South Australia
Department for Infrastructure and Transport

Practices and Requirements for Tramline Signalling on the Adelaide Tram Network

Engineering Standard

Rail Commissioner

SG2-DOC-002021

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1. Introduction

The South Australian Public Transport Authority (SAPTA) is a Directorate within the Department for Infrastructure and Transport (DIT) responsible for the delivery of public transport services. SAPTA on behalf of the department manages the Adelaide Metropolitan Public Transport Network.

The Practices and Requirements for Tramline Signalling on the Adelaide Tram Network (this standard) forms part of the SAPTA Engineering Management System and is intended to ensure that the tramline signalling system is not subject to any risks not deemed to meet the 'So Far As Is Reasonably Practicable' (SFAIRP) principles under Rail Safety National Law (RSNL).

This document is intended to be read and applied by competent rail industry signal designer engineers conversant with the practices and terminology generally employed by signalling design engineers when performing tasks based on, or broadly complying with, signalling design principles.

2. Purpose

This standard specifies the practices and requirements that must be applied to all new signalling works undertaken on the Adelaide Tram Network (ATN).

It also provides an overview of the existing signalling systems currently in use on the ATN for assessment of compatibility and integration of any new infrastructure (Appendix B).

3. Scope

The scope of this standard covers design and installation requirements and parameters to be applied to new tram signalling infrastructure.
This standard does not apply retrospectively to existing signalling on the ATN.

This document describes the general practices to be adopted when designing and installing signalling infrastructure for the tramline and is to be used by:

- Transport Project Delivery (TPD) Rail Projects
- DIT contractors
- Operator / Maintainer engineering and maintenance functional areas

4. Related Documents

DOCUMENT NAME	DOCUMENT NUMBER	COMMENT
Tram Rule Book	SQE-MAN-NIL-0002	Tram network information - Torrens Connect
Requirements for Road-Rail Vehicles Accessing and Operating on the Adelaide Tram Network	ENG-ENS-NIL-0023	Tram network information - Torrens Connect
600V DC Tram Electrical Safety Instructions	ENG-PRO-ELM-0001	Tram network information - Torrens Connect
Permit to Work	ENG-PRO-NIL-0001	Tram network information - Torrens Connect
American Railway Engineering and Maintenance-of-Way Association (AREMA) Communications & Signals Manual of Recommended Practices	Volumes 1-5	arema.org
Standard for Railway Pedestrian Crossings	CS4-DOC-000446	Technical standards for the design, construction and maintenance of rail pedestrian crossings

5. References

- Rail Safety National Law Act (South Australia) 2012
- Master Specification RW-SE-D1 Signalling
- Master Specification PC-RW10 Railways Management Planning
- Master Specification PC-RW50 Inspection Testing and Commissioning
- Master Specification PC-RW60 Asset Management Handover
- AS 7658 Part 7 Level Crossings
- AS 1742.7 Manual of Uniform Traffic Control Devices
- AS 7702 Type Approval
- AS 7770 Rail Cyber Security
- AS 7470 Human Factors Integration in Engineering Design
- AS 3000 Electrical Installations
- AS 4509 Stand-alone power systems
- AS 2144 Traffic Signal lanterns
- AS 7601.1 Light rail and road interfaces: Management of light rail vehicle movements
- Code of Practice – Rail Cyber Security for Rolling Stock and Train Control Systems
- 'Austroads' Guide to Traffic Management Part 9: Transport Control Systems – Strategies and Operations
- AS/NZS 3845 Road safety barrier systems
- 40403521: Assembly and Adjustment Instructions; Haning and Kahl HSK Blocking Circuit (H&K Manual) Homepage - HANNING & KAHL (hanning-kahl.com)
- Road and Marine Services Division; Traffic Management; Operational Instructions - Traffic Signal Faces - 14.2
- SG2-DRG-100513 'City Tram Line Extension Standard Drawing Comms & Signal - Signal Number Plate'
- Drawing 301-A2-81-118 Minimum Structures
- IEC 61508 Functional safety for electrical, electronic and programmable electronic safety related systems
- TP2-DOC-002020 Guideline for Low Voltage Electrical Earthing and Bonding for the Adelaide Metro Tram Network
- SG1-DOC-000375 Signalling Design Process and Design Production Standard for Contractors
- SG4-DOC-000455 DIT Engineering Standard for Railway Signalling Cables.
- PTS-MS-10-SG-STD-00000094 Pit and Conduit Standard for Signalling and Communication Cables
- AM4-DOC-000936 Naming and Numbering Conventions for AMPRN Rail Assets and Infrastructure
- AM4-DOC-000466 Type Approval for Railway Products
- PR-AM-GE-807 Approval of Technical Standards and Waivers
- SG1-DOC-000452 Testing and Commissioning of Signalling Systems
- AM4-DOC-000940 Asset Management Handover Requirements Standard
- AM4-DOC-000364 - Drafting requirements for Rail AutoCAD Drawings
- FR-AM-GE-806 Identification and Numbering of Public Transport Technical Documents, Records and Drawings
- PTS-MS-05-AM-PRC-00000091 Asset Management Technical Data Requirements for Projects
- ONRSR Guideline - Meaning of duty to ensure safety so far as is reasonably practicable.

6. Compliance

These practices and requirements must be applied to all new signalling works on the tramline.

Where significant alterations to existing works are required, these practices and requirements must be followed unless agreed otherwise in writing by SAPTA Asset Management.

Any third party or contractor undertaking activities related to the ATN must complete and return a compliance schedule for this standard.

Assessment of compliance must be provided for each requirement, defined by one of three permissible responses for the review and consideration of the principal:

- Compliant
- Partially Compliant (waiver may be required)
- Non-compliant (waiver required)

The delivery of a compliance schedule must be provided in addition to the development of a RAATM as described in Master Specification PC-RW30 Design.

7. Overview

The braking characteristics of a Light Rail (LR) tram system enable it to operate primarily through line of sight where the driver controls the speed of the Light Rail Vehicle (LRV) to maintain, in all circumstances, a safe distance from other track vehicles and other obstructions with respect to braking capability (excluding emergency brake applications).

The management of the safe movement of Light Rail Vehicles (LRV's) involves reducing the risk of:

- Collision between light rail vehicles, pedestrians and other road users
- Derailment
- Misrouting
- Inadvertently proceeding through incorrectly set routes

The risk of collision or derailment must be reduced to 'SFAIRP' (So Far As is Reasonably Practicable).

Under Section 46 of the Rail Safety National Law Duty Holders are required to:

- Eliminate risks to safety so far as is reasonably practicable and
- If it is not reasonably practicable to eliminate risks to safety, to minimize those risks so far as is reasonably practicable.

The Office of the National Rail Safety Regulator has provided guidance in its published guideline 'Meaning of duty to ensure safety so far as is reasonably practicable'.

Fixed signalling is provided:

- At junctions
- Depot locations to manage diverging routes
- On the approach to level crossings
- Approach to road traffic crossings

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.

8. Signalling Requirements for New Works

8.1. Design

All design work for tramline signalling must be produced in accordance with SG1-DOC-000375 *Signalling Design Process and Design Production Standard for Contractors*.

RAMS analysis must meet or exceed current levels on the tramline and consider availability of replacement parts.

Light rail signalling systems must be designed to provide:

- Explicit and consistent information to enable the LRV driver to control the vehicle within the conditions set by the indication provided
- Fail-safe functionality, such that any predictable type of failure of an item of signalling equipment does not lead to increased risk
- Maintainability of the system, such that the system can be maintained safely without creating unsafe situations for the public and maintainers
- Vandal proof protection SFAIRP
- Ability to remotely access the system and analysis fault and extract data
- Signal Passed at Stop detection at junctions
- Track detection system sequencing faults

8.2. Human factors

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 must be identified, analysed, and mitigated SFAIRP as part of the design phase.
The principles in AS 7470 must be applied when conducting any human factors assessment.

8.3. Interlocking requirement

All interlockings must have a minimum Safety Integrity Level 3 (SIL3) in accordance with IEC 61508.
Any alternative interlocking must be approved for use by SAPTA Asset Management and must be type approved in accordance with Section 10.5.

8.4. Cyber Security

Light rail signalling systems must be designed to minimize 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.

8.5. Type approval

All newly introduced or novel signalling safety equipment must be type approved.
The contractor/project manager must follow the type approval process in accordance with AM4-DOC-000466 *Type Approval for Railway Products* and AS7702 *Type Approval*.

8.6. Competency Assessment

All contractors and subcontractors undertaking rail safety work on any DIT tram signalling project must ensure those works are undertaken by competent personnel with relevant qualifications and experience commensurate with their responsibility and authority.

The Contractor shall formally advise The Principal of its nominated key personnel and rail safety workers including supporting information to demonstrate their competence to

undertake the role for review by SAPTA Asset Management and/or the operator as applicable.

The contractor will update details upon change of roles or where there are new or alternative workers brought onto the project.
Agreement or acceptance of competency records do not set a precedent for future acceptance on subsequent projects.

8.7. Pits and Conduit standard

Any CSR (Combined Service Route) work must comply with PTS-MS-10-SG-STD-00000094 *Pit and Conduit Standard for Signalling and Communication Cables* and AS/CA S009:2020 *Installation Requirements for Customer Cabling (Wiring Rules)*.

All conduits for the purpose of enclosing Low Voltage systems must be installed by or under direct supervision of a licensed electrician and a Certificate of Compliance (CoC) issued.

Communication conduit and cables must be installed or directly supervised by a registered cabler.
A registered cabler must provide a TCA1 for any Comms conduits installed.
The registered cabler must provide a TCA2 form if in the process of the installation a non-compliant communications conduit installation is identified.

8.8. Signalling Cable

All cables must comply with SG4-DOC-000455 DIT *Engineering Standard for Railway Signalling Cables*.

New cables must not have any joint in the cable length.
No direct buried cable shall be installed as part of any installation work for main or local cable runs.
This also applies to all trackside equipment installations such as track circuits, points, signals etc.

8.9. Level Crossing

The layout and configuration of all road/rail (vehicular crossings) and pedestrian crossings must comply with the requirements of Australian Standard AS 1742.7 *Manual of uniform traffic control devices - Railway crossings,* AS/RISSB 7658 *Railway Level Crossings and* CS4-DOC-000446 *Standard for Railway Pedestrian Crossings,* inclusive of any amendments and updates.

In addition:

- Flashing lights with half boom barriers and gongs represent the minimum level of protection provided within the Tramline.
- Where road traffic lights are installed at a level crossing, the road traffic lights must be coordinated with the operation of level crossing warning equipment such that the road traffic lights do not display a green toward flashing level crossing lights.
- Level crossing controls must be provided with a Manual Operation Switch located external to the level crossing location cases to enable authorised operational and maintenance staff to initiate and terminate operation of the level crossing.
- Visual warnings such as Flashing Lights must operate continuously throughout the entire level crossing operational period from initiation to completion.
- All level crossings must have adjustable gongs which can be modified to suit the surrounding environment.
- Where a new level crossing is proposed for a temporary installation to accommodate major infrastructure changes the methodology is to be agreed by SAPTA Asset Management.

8.10. Power supply arrangement

All signalling location boxes must be supplied with a redundant power supply arrangement.
Single points of failure in the design must be minimized.

The design of all power supply system and sub-systems must incorporate robust defences against lightning or other forms of surge event.
Systems that rely on the 'storage' of safety critical states or information must enforce a safe state if power is lost and subsequently restored.

Any Signalling supplies fed from the SA Power Networks supply must be isolated from the SA Power Networks system using an isolation transformer to comply with Tram E&B and dwg TP4-DRG-004185.

The Signalling Isolation Enclosures are each locally earthed using four earth stakes and a test earth point separated from the Multiple Earth neutral (MEN) system.
Earthing and bonding requirements are referenced within TP2-DOC-002020 *Guideline for Low Voltage Electrical Earthing and Bonding for the Adelaide Metro Tram Network*.

Innovative design utilsing renewable energy sources (particularly solar) and battery storage systems are encouraged.
Solar system sizing and battery storage system sizing is highly sensitive to the design assumptions and considerations.
Australian standard AS 4509 *Stand-alone power systems*, must be used for the basis of all system charging and capacity requirement calculations.

8.11. Numbering convention

All tramline projects must number new signalling equipment in accordance with AM4-DOC-000936 *Naming and Numbering Conventions for AMPRN Rail Assets and Infrastructure.*
The project numbering system must be submitted for approval by SAPTA Asset Management.
The applied naming of the equipment must be reflected in the software development and logs of the signalling system.

The identification and numbering of technical documents, records and drawings must be in accordance with FR-AM-GE-806 *Identification and Numbering of Public Transport Technical Documents, Records and Drawings*

8.12. Signal type & classification

Signals must be compliant to AS 2144 and 'Traffic Signal lanterns and Road and Marine Services Division; Traffic Management; Operational Instructions - Traffic Signal Faces - 14.2.'

All signals on the tramline network must be 'T' light signals. These must be used as an indication to Proceed or Stop.
A point bar indicator must be used to indicate the divergent route.
This signal does not provide an indication to Tram Operator to Proceed or Stop.
An amber dot signal must be used, where there is a junction, to represent the acknowledgement of the Tram Operator's selection from the tram.

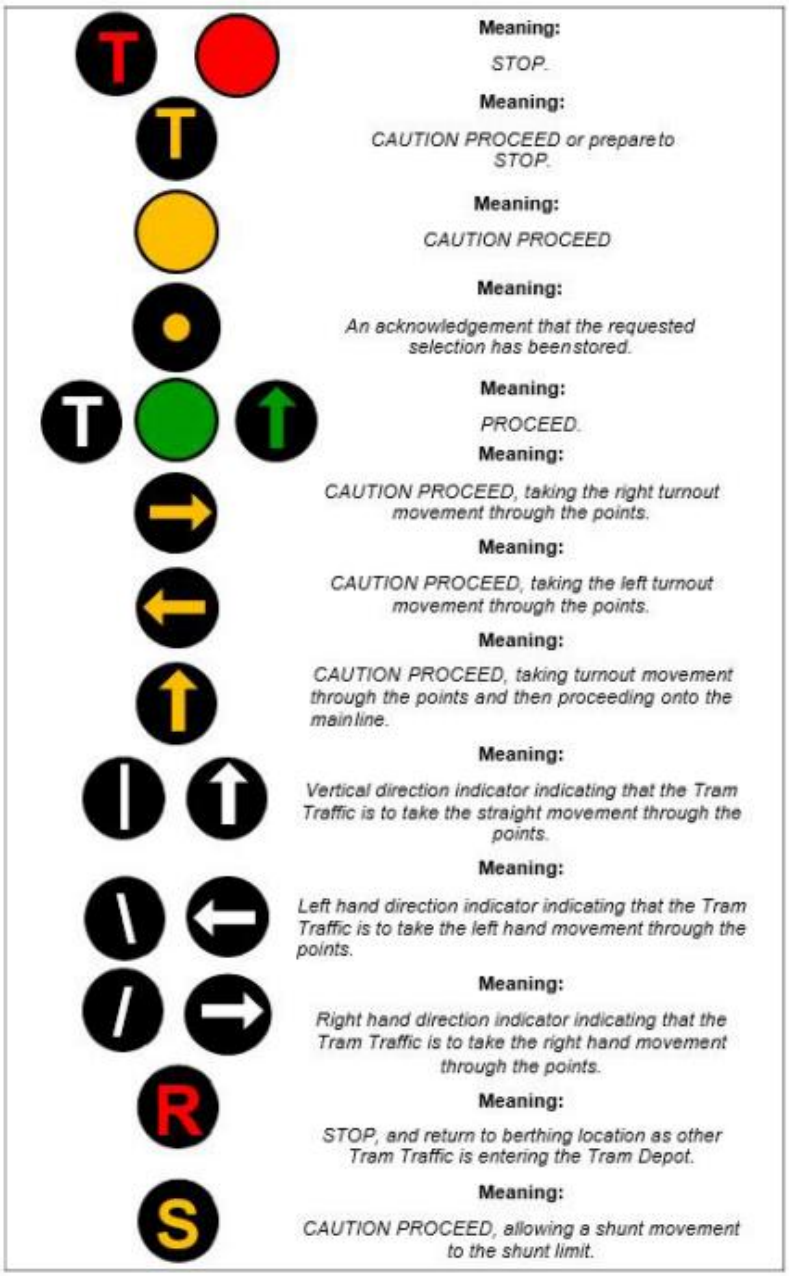
New or upgraded signals must be LED type.
(Note: AS 1742.14 provides detailed requirements and recommendations for traffic signal sighting and may be useful when assessing light rail signalling locations).

Note: Where existing colour light signals exist on the tramline that require replacement necessitating the need for an interlocking change dispensation may be provided to permit a ‘like for like’ replacement on an interim basis.

Fixed Tram Signal indications may convey information about:

- an Authority to PROCEED; or
- the condition of the section ahead; or
- the route setting.

The meaning of the above signals is summarised as below:



Where the T light signal and point bar indicator are installed on the same post, the installation must be as shown below:

Indications:

White Vertical Bar – Points set for straight ahead

White Diagonal Bar – Points set for diverting

Red ‘T’ light – Stop

White ‘T’ light – Proceed

Amber acknowledge – Request to enter has been stored

Non-commissioned Fixed Tram Signals must be identified to prevent them being mistakenly interpreted by a Tram Operator as an active Fixed Tram Signal as per Tram Rulebook SQE-MAN-0002; 2.6 Non-commissioned Fixed Tram Signals.

A Fixed Tram Signal or other signalling equipment must not be tested if Tram Traffic is closely approaching, and the testing could change the Fixed Tram Signal indication. Refer to Tram Rulebook SQE-MAN-0002; 2.7 Testing Fixed Tram Signals.

8.13. Signal sighting

Signal height and location must be as per 9.3 in this standard.

Signal sighting is not an exact quantitative process. Much of the input data is opinion and experience based and, therefore, subjective, and qualitative in nature. Consensus is required between the Operator and SAPTA for agreed sighting distance taking into consideration:

- Maximum designed track speed
- LRV service braking capabilities
- LRV driver reaction time
- LRV driver direct line of sight
- Environmental conditions (sun glare)

Light rail signals must be located so they can be clearly identified by the LRV driver from the:

- Driver’s normal eye position
- Agreed sighting distance

Clear identification by the driver may be achieved by:

- Reducing visual clutter
- Reducing potential visual conflicts, including conflicting signal indications
- Standardisation of indications
- Standardisation of signal position

8.14. Point machine

Any proposed alternative point machine, not currently in use on the ATN, must be type approved in accordance with Section 8.5.

8.15. Vehicle detection – HSK Track circuits

HSK blocking circuits are used on the shared (in street) section of the tramline.
HSK blocking circuit must be installed with 6 boxes for each circuit, each box as shown in 'Appendix A'.
All cables for the HSK circuit must be in conduit for future replacement and all connections to rail must be readily accessible and maintainable from the HSK rail boxes.

8.16. Drainage Installation for signalling equipment:

In the shared (in street) section of the tramline, drainage must be installed at heels and point of blades to prevent water running into the point machine.
Drainage must also be installed within each point machine to allow any water ingress to clear from the machine.
A drain must be installed between the rails before the point of blades to capture all water and debris before it reaches the point blades.

Where H&K blocking circuits are being installed, then each rail box of the H&K blocking circuit must be installed with drainage.
Drainage must be designed in such a way that water cannot back up into any signalling equipment or boxes.

8.17. Route selection

PLC's / interlockings must be provided for route selection where more than one route is available at junctions or depot areas.
They must be activated using either on-board driver route selection or a mechanical button from the wayside or via telemetry from a computer based interlocking system or various combinations of all three.

8.18. Single line sections

Line of sight movement permission must not be used as the only form of managing movement on bi-directional single running lines.

8.19. Interface with traffic system

Any road traffic interface to a junction area must be approved by SAPTA Asset Management and DIT Network Management Services (NMS).
Any interface document/design decision must be recorded as part of the interface agreement. This document must be produced by the contractor.

8.20. Road traffic signals

Traffic Light Coordination is provided at level crossings where an interface is required into the adjacent road traffic light system.
An interface is provided to provide advanced warning to the traffic light controller to prepare the road lights for the level crossing operation.

The following outputs are normally provided to the crossing controller:

- Force to red (FTR)
- Advance Warning
- Minimum Green
- Boom Gates Rising

In preparation for the possible fitment of red light cameras a suitable voltage free single-cut circuit is required between two outgoing terminals to indicate when the road lights are flashing.

Phasing and sequencing of traffic signals must be determined by risk assessments, detailed risk controls, operational requirements, protocols and standards as documented between the Commissioner of Highways or Local Council Authority and rail transport operator / SAPTA).

The timing between phases should be calculated in accordance with 'Austroads' Guide to Traffic Management Part 9: *Transport Control Systems – Strategies and Operations,* the RTO's operational requirements and the road authority policies and guidelines. Phase timings are generally based on road vehicle performance and pedestrian behavior.

As-built Tram-Traffic interface circuits must be provided to the principal.

8.21. New or modified LRV's

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

8.22. Removal of existing tram infrastructure

The project must ensure removal of existing infrastructure is undertaken in a manner which minimises damage to serviceable components of the existing systems and deliver these components (which remain the property of DIT) to their nominated site.

8.23. Failure situations

Prior to handover procedures must be examined to ensure safety and operational arrangements are in place to allow continued operations due to equipment failure or degraded mode of operation.
Where there is a deficiency in the procedures they must be modified, or new procedures developed.

Procedures must cover as a minimum:

- LRV failure
- Traffic signal failure
- Light rail signal failure
- Points failure

These requirements must be described in the Asset Handover Plan in accordance with PC-RW60 Asset Management Handover and AM4-DOC-000940 *Asset Management Handover Requirements Standard*.

8.24. Training

A Training Needs Analysis (TNA) must be developed by the Project and must be submitted for approval to SAPTA Asset Management.
Training must be in accordance with Master Specification PC-RW10 Railways Management Planning, Asset Management Technical Data Requirements Specification; AMTD-Operations-1-2-Training.

Where the TNA identifies familiarisation is required, that familiarisation must be delivered by a suitably qualified subject matter expert.

8.25. Spare parts

The quantity of spares will be determined from an analysis of historical data, price, lead time, supplier recommendation, and criticality. Additional spares must be provided where the requirement is identified during the RAMS analysis carried out by the Project.

8.26. Specialised tools

Where there is a requirement for access, monitoring, or intervention by the operator on newly provided infrastructure requiring the use of 'specialised tools' the project will provide those tools.
This refers to all specialised apparatus, either purchased, custom made, or modified above that which would be considered conventional tools.

The requirements of Asset Management Technical Data Requirements Specification; AMTD-Build-1-6-Special Tools/Test Equipment must be complied with.
Before using specialised tools training in safe use must be included for consideration within the TNA.

9. Installation and Construction Requirements

9.1. HSK Blocking circuit installation

HSK blocking circuits must be installed with H&K rail boxes in a 6 rail box arrangement with 3 on each side between the tracks as described in the 40403521: H&K Assembly and Adjustment Instructions; Haning and Kahl HSK Blocking Circuit (H&K Manual).

All cables for the HSK blocking circuit must be installed within conduits between the rail boxes and be able to be replaced for maintenance activities.
All connections to the rail must be Cembre connections in accordance with the H&K manual.

This includes the end shorting straps that will require an additional 2 H&K rail boxes when installed in this configuration.
The standard installation of blocking circuits is described in 'Appendix A'

9.2. Signal Disconnection box

All signals must have a disconnection box adjacent to the signal which must be connected to the location box via a pit and conduit system.
The signal head must connect to the location box via the disconnection box only.
The disconnection box must have lockable lids/doors and allow easy access above ground level.

9.3. Signal height and location

All mainline signals must be restored to display their most restrictive aspect as soon as practicable after the front bogies of the tram pass the signal.
This requirement must be balanced with further requirements to ensure that the driver of the tram cannot see the signal being replaced by their own tram and to allow a practical construction tolerance (e.g. positions of IRJ relative to rail welds or positioning of an axle counter head).

All signals must be installed at a minimum clearance allowing for kinematic effects for the trams in accordance with 301-A2-81-118 *Minimum Structures* (Knet# 10712581).

Signals that are applicable to a particular movement are normally located on the driver's left except where specified to the contrary, e.g., signals at the Union are

displayed to the RIGHT of the Tram Operator due to site and signal sighting constraints.
Signals are normally the height of a normal roadway traffic signal.
Wherever possible signals should not be mounted on anything other than DIT owned poles (posts).

9.4. Signal identification

All signals must be installed with a number plate in accordance with DIT drawing SG2-DRG-100513 '*City Tram Line Extension Standard Drawing Comms & Signal - Signal Number Plate*' (Knet 14533079).

9.5. Location box

All signalling location boxes must be within the tram corridor.
Any requirement for the installation of a location box outside of tram corridor requires approval from SAPTA Asset Management.
If approval is granted the location box must be protected against any damage by road traffic by physical barriers such as bollards in accordance with *AS/NZS 3845 Road safety barrier systems*.

Location box orientation must allow safe access to open doors in a manner that reduces exposure to rail or road traffic.
Location box height must allow for ease of inspection and unit changeout.
All location boxes must have engraved identification plates installed on the doors.
Location boxes must be provided with a redundant power system architecture in congruence with 8.10. Power supply arrangement.

9.6. Equipment and System Security

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

The design deliverables for each stage of works must be as per SG1-DOC-000375 Signalling Design Process & Design Production Standard for Contractors and Master Specification RW-SE-D1 Signalling.

Deliverables must be in accordance with PC-RW60 Asset Management Handover
A RAATM must be delivered in accordance with PC-RW30 Design

At the end of the project As-built drawings must be submitted to SAPTA Asset Management within four weeks of final commissioning of project.

All drawings/designs must comply with AM5-DOC-003408 - *Drafting requirements for SAPTA Drawings* and FR-AM-GE-806 *Identification and Numbering of Public Transport Technical Documents, Records and Drawings.*

11. Testing and Commissioning

Testing and commissioning of all new and modified signalling works must be undertaken in accordance with Master Specification Part RW50 *Railways - Inspection, Testing and Commissioning* and SG1-DOC-000452 *Testing and Commissioning of Signalling Systems*. All test results must be made available as a deliverable.

12. Asset register

The Asset Register must clearly define all new assets, modified assets, and decommissioned assets as part of the project.

An Asset Register / Product breakdown Structure must be provided in accordance with Master Specification PC-RW60 Asset Management Handover and the referenced *PTS-MS-05-AM-PRC-00000091 Asset Management Technical Data Requirements for Projects. In particular:*

- AMTD- DESIGN-1-1 Preliminary Product Breakdown Structure – Modified Baseline
- AMTD- DESIGN-1-2 Preliminary Product Breakdown Structure – Greenfield Projects
- AMTD- BUILD-1-8 Final Breakdown Structure

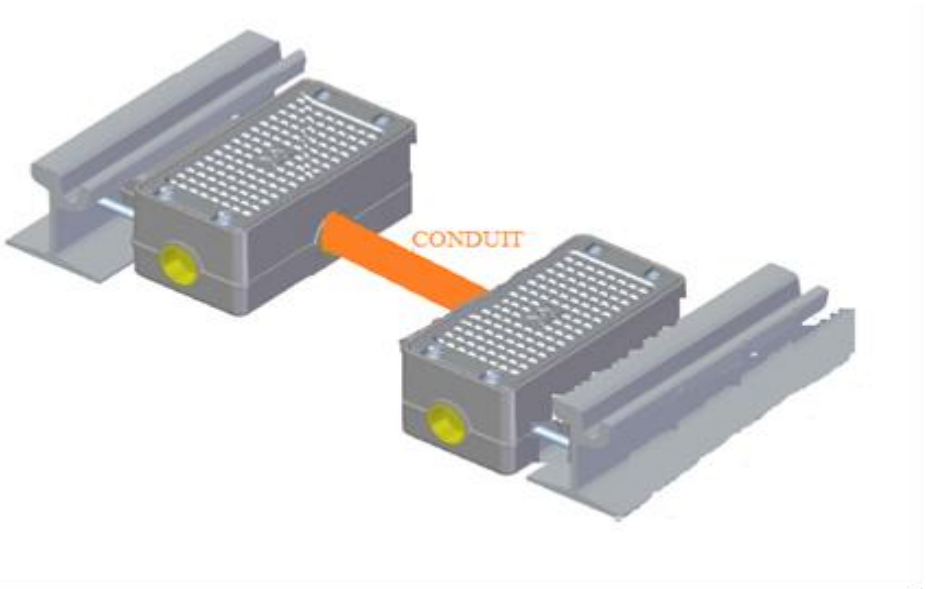
13. Asset Handover

Asset handover must be undertaken in accordance with AM4-DOC-000940 *Asset Management Handover Requirements Standard.*

Asset information and technical documents, drawings and records must be delivered to the Rail Infrastructure Management information custodians in accordance with PTS-MS-05-AM-PRC- 00000091 - Asset Management Technical Data Requirements Specification and Master Specification RW60.

APPENDIX A - BLOCKING CIRCUIT INSTALLATION

All cables for the HSK blocking circuit must be installed within conduits:

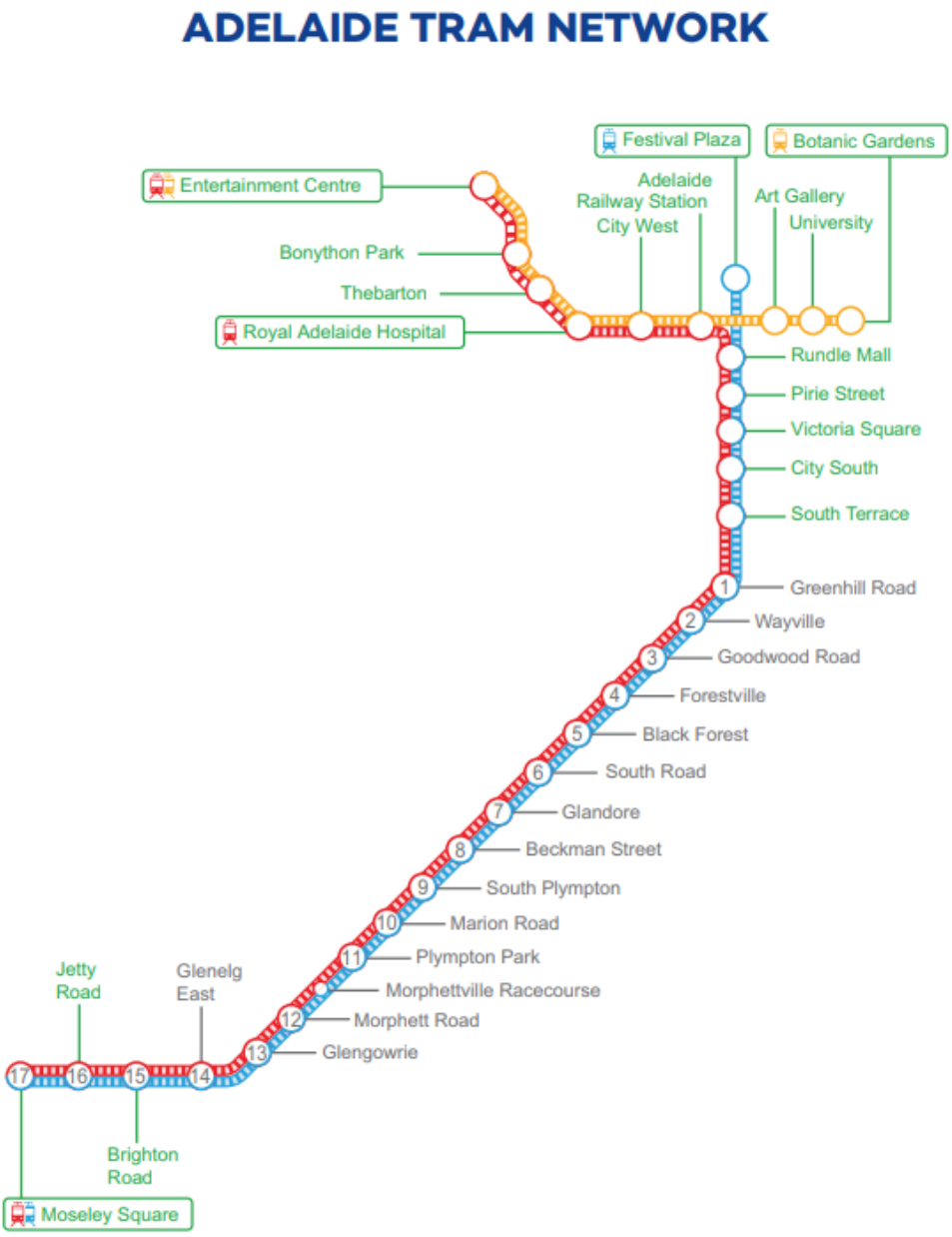


APPENDIX B - DESCRIPTION OF EXISTING SIGNALLING SYSTEMS ON THE TRAMLINE

Signalling on the tramline currently consists of relay interlocking, H&K (Hanning & Kahl) tram signalling or a combination of both.

The tramline system consists of the following lines:

- Glenelg Line – between Adelaide Railway Station (ARS) and Glenelg
- Hindmarsh Line – between ARS and Adelaide Entertainment Centre (AEC)
- EastLink – between ARS/The Union and Botanic Gardens
- Festival Plaza Link – between Glenelg/The Union and Festival Plaza



The closed section of the tramline (i.e., ballasted track) is the section from South Terrace to Brighton Road.

The shared section of the tramline (i.e., in street tracks) comprises:

- The section from South Terrace to AEC
- From The Union to Festival Plaza and The Union to Botanic Gardens

- Brighton Road to Moseley Square

B1 ARS to AEC and South Terrace; The Union to Botanic Gardens and Festival Plaza, Brighton Road to Mosley Square

Within this shared section of the tramline, trams operate intermixed with road traffic and the H&K tram signalling system controls movements at the Adelaide Entertainment Centre, West Terrace tramstop, Botanic Gardens & Festival Plaza.

The H&K tram signalling system is Safety Integrity Level 3 (SIL3) type interlocking which allows trams to travel over the sets of points on different routes, provided it is safe, and all conditions are met. The crossovers at the tramstops at AEC, West Terrace, Botanic Gardens and Festival Plaza have their own independent H&K interlocking signalling systems.

At Botanic Gardens, Festival Plaza and The Union, the H&K signalling system interfaces with the road traffic signalling system. The H&K system sets the points for the requested route provided it is safe and all conditions are met. The H&K system then sends input to the traffic signalling system to clear the 'T' lights for the tram, provided there is no other conflicting move. The road traffic control system provides the final signal authority for a tram to proceed.

The H&K Controller and HCS-R/V communication system is described in further detail in section B7 below.

B2 South Terrace Junction

The South Terrace signalling system consists of relay interlocking and an HCS-R communication system for route selection and tram operation. The Tram Operator selects the route on the approach to the signal which has more than one route available. Request commands are sent through the receiver loop to the HCS-R communication system.

The HCS-R relay will then send a request to the relay interlocking. The relay interlocking then Clears/Stops the signal depending on the tram movement and other conditions.
If there is an issue in selecting the route directly from the tram the Tram Operator has the option of selecting the route from the push button box provided at the signal post or platform box.

The signal clears to a green arrow for the straight route or yellow arrow for the diverging path where there is more than one route. Where there is a single route only, the signal will clear to green or yellow.
The entrance/exit of the route is detected by a receiver loop. There is no blocking circuit arrangement or track circuit provided within the South Terrace area.

B3 South Terrace to Brighton Road

This closed (i.e. ballasted) section of the tramline has signalling at:

- South Terrace Junction
- Approaches to all level crossings
- Glengowrie tram depot

B4 Level crossings on tramline between South terrace and Glenelg

There are 7 level crossings on the tramline at the following road/tram intersections:

1. Goodwood Road (LX29)
2. Leah Street (LX39)
3. Beckman Street (LX59)
4. Marion Road (LX69)
5. Cross Road (LX79)
6. Morphett Road (LX 89)

7. Sixth Avenue (LX99)
All level crossing approaches are fitted with TI21 track circuits for the correct operation of the level crossing for single or two tram movements. All level crossings are protected by signals on the up and down lines.

There are no track circuit installations for tram detection outside of level crossing approaches except on the approach to Glengowrie depot to allow tram movement in and out of the depot.

B5 Glengowrie Depot

Glengowrie depot is the main tram operations and maintenance depot located next to Morphett Road level crossing. The mainline trackwork at Glengowrie depot has been installed with TI21 track circuits, points and signals to allow tram movements in and out of the tram depot. Signalling in this area is performed by relay interlocking.

Signals on the main line clear automatically when a tram occupies the approaches to the signal for main line movements. The Tram Operator must stop and request permission from Tram Control to enter Glengowrie depot.

There is a manual control box from which a qualified employee can, if required, operate the signals and point machines to allow a tram movement.

There are no track circuits within the depot area. All tram movements within the depot are performed under local operational procedures in accordance with the Tram rule Book.

B6 Point Machines

HW61 AVV-ZVV – H&K Electric point machine

A point machine of the type HW61 AVV-ZVV with lock, tongue detector and lever box switch. This setting mechanism can be trailed. The operating voltage is 600V DC overhead line voltage.

HWU 40 D-Z – Manual point machine

A manually operated point machine of the type HWU40 D-Z without lock, but with tongue detector. This setting mechanism can be trailed. The machine spring returns to a normal lie for the straight route.

HWU 40 D – Manual point machine

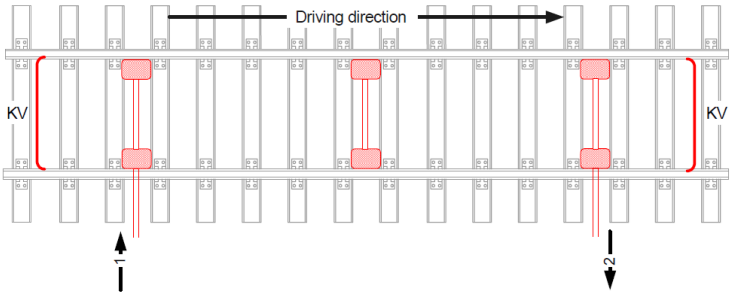
A manually operated point machine of the type HWU40 D without lock. This setting mechanism can be trailed.

B7 Hanning & Kahl Controller and HCS-R/V communication system

This is a software based interlocking/controller which will allow/stop a tram depending on the conditions for safe tram movement. The communication system HCS-R consists of vehicle and wayside equipment. Data transmission between the tram and the controller is one-way.

B8 Block circuit

Hanning HSK blocking circuits are used for the passive detection of a rail vehicle in a track area. The HSK component is part of the Vital Processor HN-P and can only be used in connection with that system. A HSK blocking circuit is “occupied” upon wheel shunt and becomes “free” again when vehicle mass is no longer present.



1 – Lead (output of the HSK component)
2 – Lead (input of the HSK component)

Image courtesy of Hanning & Kahl GmbH & Co KG 2006

Occupied blocking circuits are recognised by a change in amplitude; the clearing of blocking circuits are recognised by a change in the operating frequency.
HSK blocking circuits with different frequencies are deployed to rule out mutual influencing. The operating frequency of the HSK blocking circuit is in the range from 20 to 30 kHz. The frequency of the loops are separated by 2000 Hz to prevent interference from adjacent blocking circuits.

B9 Transponder Loop

The transponder loop allows the tram operator to select the route over a set of points. Transmission of the command for the route request is sent through the transponder via the receiver loop to the communication system which will clear/stop the signal depending on the condition of the point machines and the block circuit.

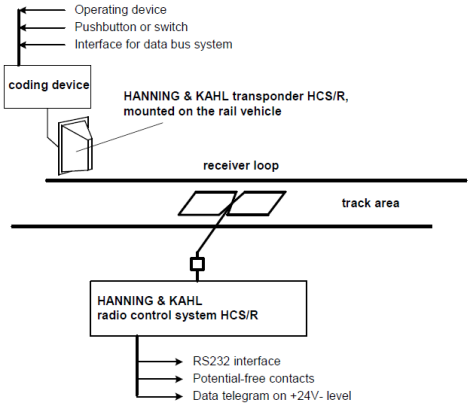


Image courtesy of Hanning & Kahl GmbH & Co KG 2006