LIGHT RAIL
Safety and Standards Board

Network Supervision and Management Guidance

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DESCRIPTION:

THIS DOCUMENT PROVIDES DESIGN GUIDANCE RELATING TO THE OPERATIONS AND MANAGEMENT OF NETWORK'S SERVICES AND ASSETS

EXPLANATORY NOTE:

LRSSB is not a regulatory body and compliance with this guidance document is not mandatory. This document reflects good practice and is advisory only. Users are recommended to evaluate this guidance against their own arrangements in a structured and systematic way, noting that parts of this guidance may not be appropriate to their operations. It is recommended that this process of evaluation and any subsequent decision to adopt (or not adopt) elements of this guidance should be documented. Compliance with any or all of the contents herein, is entirely at an organisation's own discretion.

SOURCE / RELATED DOCUMENTS:

LRG 1.0 Tramway Principles and Guidance (TPG) (LRSSB)
LRG 6.0 Fatigue Management Guidance (LRSSB)
LRG 8.0 Guidance in the Management of Vulnerable Persons (LRSSB)
LRG 21.0 OLE Maintenance and Reference Manual (LRSSB)
LRG 28.0 Guidance on the Provision of Accessibility in Light Rail Systems (LRSSB)
LRG 29.0 Guidance on Human Factors in Operations Control Centres (LRSSB)
LRG 30.0 Depot Control Centre Guidance (LRSSB)
LRG 32.0 Testing and Commissioning Guidance (LRSSB)

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NETWORK SUPERVISION AND MANAGEMENT GUIDANCE

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TERMS AND ABBREVIATIONS

Table A – Terms

Term	Definition
Consents	All permissions, consents, approvals, certificates, permits, agreements, licences and authorisations etc., together with all conditions as required for the performance of any of the contracting parties' obligations under procurement agreements.
Contracting Parties	The entities party to the procurement of works and project operations of the network.
Degraded Operating Conditions	Occur when either a part or some parts of the tramway system continue to operate in a restricted manner over a period of time with additional controls in place.
Emergency Situation	A situation or circumstance which requires immediate or urgent action in order to maintain safety or restore the effective operation of the network.
Maintain / Maintenance	Planned and responsive inspections, maintenance, servicing, cleaning, repair, renewal, refurbishment and replacement etc.
Network	The existing system as extended by the carrying out of the works including existing and new trams together with all associated infrastructure, plant, machinery, apparatus, equipment, furniture, street furniture, facilities, track, station and tramstop structures and platforms, depot buildings, OCC, P&R sites, electrical sub-stations, OLE equipment (including bases and poles, building fixings and wiring), CCTV system, network supervision, control (including signalling) system, spares, consumables, administrative offices and office furniture and office equipment in such administrative offices etc.
Normal Operations	The way in which the tramway was designed to operate within its specified operation parameters in accordance with its Safety Management System.
Ofcom	The UK's communications regulator.
Operations Control Centre	The room / area where specific management of the operation of the tram (Light Rail) service is performed.
Operations Control Room	The building where tramway operations are managed.
Opsco	The contracting party responsible under the procurement arrangements for the project operations, delivery of the services and maintenance of the network after the works and who supports the design and construction subcontractor during the works period.
Performance Measures	All measures, indicators and output requirements designated to successfully deliver the sServices and / or project operations.

Term	Definition
Powertrain	The mechanism that transmits the drive from the engine of a vehicle to its axle.
Project Operations	The carrying out of the design and the works for the implementation / delivery of the services.
Project Operations Staff	Any employees, contractors, consultants or other personnel engaged from time to time in the provision of the project operations.
Promoter	The party who is seeking to develop and implement the network or modifications to an existing network.
Safety Management System	A formal management system or framework to manage health and safety.
Services	The provision of public passenger tram services on the network.
Supervisory and Control System	The computerised system used by project operations staff to supervise and manage the project operations and deliver the services.
Tram Location and Detection System	Part of the supervisory and control system responsible for monitoring and displaying the location and movement of trams and other vehicles used for the project operations.
Tram Location and Detection Subsystem	A sub system that is part of the supervisory and control system responsible for monitoring and displaying the location and movement of trams and other vehicles used for the project operations.
Works	The design, construction, testing, commissioning, completion and bringing into operation of the network, as defined in procurement agreement(s) including the design, construction, testing, transportation, delivery, commissioning and bringing into operation of new trams, all necessary modifications to existing network and / or existing trams, any temporary works and any works necessary to gain access to the Land and any widening of the highway and the system integration works and obtaining all necessary consents and enable the contracting parties to provide the full services.

Table B – Abbreviations

Abbreviation	Definition
AC	Alternating Current
CCTV	Closed Circuit Television
DC	Direct Current
HCI	Human Computer Interface
IEEE	Institute of Electrical and Electronics Engineers
IT	Information Technology
LRSSB	Light Rail Safety and Standards Board
MVC	Mobile Voice Communications
NMP	Network Management Plan
NSMP	Network Safety and Security Management Plan
OCC	Operations Control Centre
OCR	Operations Control Room
ODT	Operational Data Telecommunications
OLE	Overhead Line Equipment
OSI	Open System Interconnect
P&R	Park and Ride
PA	Public Address
PEHP	Passenger Emergency Help Point
PID	Passenger Information Display
PMS	Performance Monitoring System
RIU	Remote Interface Unit
ROGS	The Railways and Other Guided Transport Systems (Safety) Regulations 2006
RVAR	Rail Vehicle Accessibility Regulations (Non-Interoperable Rail System) Regulations 2010
SCS	Supervision and Control System
SMS	Safety Management System
TLDS	Tram Location and Detection System
TLDSS	Tram Location and Detection Subsystem
TPG	Tramway Principles and Guidance
TVM	Ticket Vending Machine
UK	United Kingdom
UPS	Uninterruptible Power Supply
UTC	Urban Traffic Control
V	Volts

1 Introduction

1.1 This guidance supports the high level principles set out in LRG 1.0 Tramway Principles and Guidance (TPG) published by the Light Rail Safety and Standards Board (LRSSB).

1.2 This document provides guidance on network supervision and management for those delegated this responsibility in relation to UK tramways (Light Rail systems) based on 'line-of-sight' operations only. As with all guidance, this document is not prescriptive and is intended to give advice not to set a mandatory industry standard, and it is based upon goal setting principles as best practice.

1.3 Much of this guidance is based on the experience gained from existing UK tramways and from published documents. It does not prescribe particular arrangements adopted by any existing UK tramways and is intended to give guidance and advice to those involved in network supervision and management.

1.4 This guidance is not intended to be applied retrospectively to existing tramways. However, promoters and operators should consider and assess any implementation of this guidance and / or any subsequent revision, to ensure continual improvement, so far as is reasonably practicable.

1.5 This guidance should be read and applied in conjunction other principles and guidance, in particular, the following:

- Operational planning / modelling;
- Operations and maintenance requirements / guidance; and
- The network's Safety Management System (SMS).

2 Scope

2.1 This document provides high-level and impartial principles and guidance in relation to safely and efficiently fulfiling the project operations after the successful conclusion of any works which are needed to implement or modify a network.

2.2 As such, this document provides guidance in relation to the following:

- Supervision and management of the project operations and network assets; and
- Systems, technologies and / or supporting processes to plan for and implement project operations.

2.3 In so doing, this document describes:

- The role of the contracting party undertaking supervision and management (the Opsco);
- The services and their performance;
- Asset management and performance;
- The role and functionality of the Operations Control Centre (OCC);
- The functionality and composition of the Supervision and Control System (SCS) to support OCC functions; and
- Technologies which deliver the necessary network security requirements.

2.4 The main context of this document assumes the adoption of current-state-of-the-art technology and systems. However, Section 9 recognises that alternative technology is becoming available and as such, describes the impact of adopting such approaches in comparison to current technology.

2.5 Although this document does not provide exact details, for example, in relation to dimensions or quantities etc., as they need to be applied on a scheme specific basis. However, some detail has been provided as a guide based on best practice.

3 Context

3.1 This guidance document applies to the supervision and management of the project operations of a network which has been certified as suitable to provide public passenger services under ROGS, or another equivalent verification and validation process. As such, supervision and management for this document is defined as the following:

- Supervision and management of:
  - The services, and all other rail vehicle movements on the network;
  - The safety and security of project operations staff, passengers, and other members of the public and highway users who interact with the network and project operations; and
- Management and maintenance of the network's assets.

3.2 The following are two key principles to support the above:

- There is an OCC from where all project operations are managed (see LRG 29.0 Guidance on Human Factors in Operations Control Centres and LRG 30.0 Depot Control Centre Guidance for guidance relating to OCC layout, and Section 5 for functionality guidance); and
- An appropriate SCS should be in place to safely and efficiently support the execution of project operations (refer to Section 6).

3.3 As trams are driven on 'line of sight' in a manner similar to road vehicles, this offers greater operational flexibility allowing, for example, trams to travel closer together but within the stopping capability of the vehicle. Tram drivers are required to operate the tram at a speed that allows them to stop the tram in a distance that they can see to be clear ahead as with the operation that road vehicle drivers apply, and allows trams to operate in close proximity to pedestrians and road vehicles. Conflict points such as intersections between tramways, roadways and footpaths are designed and operated on highway principles.

3.4 This document assumes all tram drivers hold any / all required competencies which evidence they are proficient in the following:

- The network's pertinent safety rules, regulations and procedures;
- Are suitably familiar with the characteristics of the:
  - Tram(s) they are required to drive; and
  - Route(s) they are required to drive trams over.

3.5 This guidance also assumes that all project operations staff hold any / all required appropriate specific licence(s) or certification necessary as issued by the Opsco upon successful completion of any theoretical and practical training course(s) which evidence they are proficient in any and all aspects of the project operations which they may be called upon to undertake.

3.6 The appropriate and necessary management plans are assumed to be in place to effectively and safely manage the project operations. Typically, these would, as a minimum, include the following:

- Network Management Plan (NMP) (refer to Section 4);
- Network Safety and Security Management Plan (NSMP); and

- Network SMS.

3.7 It is also assumed that the trackwork, power supply and distribution of the network are suitably configured such that the following is available:

- The services can be provided:
  - In normal mode whereby the services are per the published timetable and delivered in accordance with the performance measures; and / or
  - Under foreseeable disruptions where temporary or emergency timetables are required (for example, degraded operating conditions); and
- Project operations staff in the OCC can:
  - Monitor the general movement of the trams in real time by means of the Tram Location and Detection Subsystem (TLDSS);
  - Precisely locate the trams in real-time on a visual display in the OCC; and
  - Enter into communications with tram drivers.

4 Network Management Plan

4.1 It is good practice for the contracting parties to produce, agree and implement a NMP at the commencement of the procurement agreement and then ensure this is kept this up to date throughout the terms of the contract.

4.2 Typically, where such procurement entails design, development and implementation of new network or modifications to an existing network, once the NMP has been produced, updates to the plan would be envisaged in time for the required review and gateway processes including the following:

- Preliminary design work and critical design work;
- Section trial running (refer to LRG 32.0 Testing and Commissioning Guidance); and
- Section proving tests and network integration tests (refer to LRG 32.0) as a minimum; and
- By the Opsco annually or when a change to the network and / or the services and / or project operations is proposed.

4.3 Where a network change is proposed, such change will need appropriate verification and validation and therefore some or all of the above items would be required.

4.4 The NMP would describe all aspects of the scheme relating to the provision and delivery of the services and the management of the network's assets and would, as a minimum, include the following elements.

Service Provision

4.5 Under this section of the NMP, the Opsco would provide, as a minimum, the following from their SMS:

- The process for integration of any existing operational procedures with all applicable new or changed operating procedures to form common operational procedures;
- The operational procedures for providing and performing the project operations;
- Arrangements for staff training and competence assessment of all project operations staff engaged in the project operations and / or the works, including the core competencies applicable to all such staff;
- Contingency planning, disaster recovery and major incident management procedures;
- Procedures for managing disruption to the services;
- How replacement bus services or alternative transportation would be provided and managed when required;
- Performance indicators, monitoring and reporting;
- Health and safety procedures;
- Provision of appropriate technical resource; and
- The arrangements for normal, abnormal and degraded operating conditions and also emergency situations.

Network Security

4.6 Under this section of the NMP, the contracting parties would provide details of the following:

- Security policy and objectives for the network;
- Securing the network by design;
- Surveillance and assistance methods and level of resource appropriate to each site, such as the following:
  - Passive surveillance;
  - Active surveillance technologies (for example, closed circuit television (CCTV));
  - Mobile patrol security personnel;
  - Dedicated CCTV surveillance personnel;
  - Site located security personnel;
  - Assistance facilities (for example, passenger emergency help points (PEHPs));
  - The total number of hours of monitoring to be provided by the contracting parties' dedicated security personnel each month split by the relevant surveillance monitoring outlined above;
  - Policing arrangements;
- Partnership arrangements and initiatives, for example, crime partnerships;
- Security incident procedures; and
- Methods of monitoring the performance and effectiveness of the dedicated security personnel.

4.7 As a minimum, each update of the network security element of the NMP would take into account the following:

- Actual level of crime on and around the network, including car crime at any Park and Ride (P&R) sites, vandalism and graffiti, crime against individuals and property;
- Actual level of supervision provided over the previous period against that planned;
- Progress on obtaining Park Mark[1] at each P&R site and the recommendations made by the Park Mark assessors;
- Feedback and analysis of security matters in any customer satisfaction survey and awareness survey conducted in accordance with the performance measures;
- Feedback and analysis of customer comments relating to security;
- Recommendations of the police and / or any advisory committee; and
- Progress in respect to any national, regional or local partnerships or initiatives.

Asset Management and Maintenance:

4.8 Under this section of the NMP, the contracting parties would as a minimum, provide details of the following:

- Responsibilities of the contracting parties during the project operations and works periods;

1 The Safer Parking Scheme | Park Mark https://parkmark.co.uk/

- Where this scheme is an extension to an existing network, the process for integration of existing asset management and maintenance procedures with all applicable new or changed maintenance procedures to form common network maintenance procedures;
- Procedures for staff training and competence assessment of all project operations staff engaged in the maintenance of the network, including the core competencies;
- Procedure for maintaining, renewing and refurbishing the assets;
- Procedures for minimising disruption to services as a result of maintenance;
- Procedures for the management of endemic faults whilst minimising effects on the operation of services;
- Procedures for the feedback of corrective actions into the maintenance regime;
- Procedures and reporting format for inspections;
- Provision of an inspection programme;
- Provision of a rolling (for example, five year) forecast of maintenance work to be carried out;
- The scope and scale of renewal, replacement and or refurbishment works for each asset on the network;
- A programme of works covering the intended stages of major renewal or refurbishment of the network's assets;
- Any co-ordination constraints or opportunities for third parties including any Local Highway Authority(ies) and relevant statutory undertakers; and
- Any proposed service disruptions.

Asset Maintenance Plan

4.9 In support of the NMP, the contracting parties should produce, submit, implement an Asset Maintenance Plan and then keep this up to date as a minimum annually, including any subsequent changes from the promoter(s).

4.10 The Asset Management Plan would set out the asset maintenance requirements inclusive of both the infrastructure and tram requirements.

4.11 The Asset Maintenance Plan would provide the following:

- Set out objective plans and specifications for maintenance from the preoperational period and over the project operations period; and
- Describe the desired approach to developing an Asset Maintenance Plan, and to delivering a maintenance service including planned inspections and interventions, lifecycle replacement and response to unplanned equipment failures and damage for whatever reason.

4.12 In response to the Asset Management Plan, the contracting parties would develop a maintenance specification that details its commitment and proposals to support and enable the network to provide the services and project operations, and manage and maintain the network in accordance with the performance measures.

4.13 The Opsco would typically update the Asset Maintenance Plan in the light of operational experience in agreement with the promoter(s).

5 Operations Control Centre

5.1 Whilst LRG 30.0 describes the functionality and potential layout and building requirements for the OCC, this guidance describes the responsibilities of the OCC and means by which project operations staff in the OCC are able to safely and efficiently execute their aspects of the project operations. LRG 29.0 provides guidance on undertaking a human factors study at the design stage or when there is a significant change to the OCC or systems.

Operations Control Room (OCR)

5.2 The Operations Control Room (OCR) is the place where all supervisory, control and communication activities are undertaken and through which all operational voice communication is routed, as illustrated in Figure 5.1. It should comprise all means and equipment necessary to ensure that OCR staff can safely and efficiently manage the following through a suitable Human Computer Interfaces (HCIs) (as described in Sections 6.28 to 6.72):

- Movement of trams, or other authorised rail vehicle over the network;
- The electric traction power supply for the entire network; and
- All remotely located equipment.

Figure 5.1 Typical Operations Control Room

OCR Staff Interface and Equipment

5.3 The SCS must provide OCR staff with workstation controls that are fit for purpose and intended for use only when the network is disrupted, for example the following:

- In emergencies or during engineering works;
- Equipment failure conditions; and / or
- At the exit and entrance of trams to / from the depot etc.

5.4 All system interfaces with OCR staff must be designed and implemented in such a way as to not compromise the safe provision and delivery of the services in accordance with the performance measures.

5.5 Under normal operating conditions, the TLDSS interface would automatically control signals, points and the routing of the services without the intervention of OCR staff.

5.6 The SCS should provide an interface with OCR staff such that when an operator enters a request / command for any individual device control, the remote equipment should generate the associated output signal, in the field, in no more than 2.5 seconds.

5.7 In addition, the SCS should provide an interface with OCR staff such that when an operator requests a display, the completed display should appear on the screen in not more than 2 seconds.

OCR Workstations

5.8 SCS workstations should, as far as reasonably practicable, conform to the following:

- All be identical so that should one workstation fail, any operator can move to an alternative workstation and reconnect to the SCS by inputting their login at that new workstation;
- Are located within line of sight of each other to allow visual signals to be given between OCR staff;
- Have a clear and unobstructed view of the central TLDS overview display;
- Are furnished with modern ergonomic furniture to reduce fatigue; and
- Have personal storage.

OCR Staff Human Computer Interface (HCI)

5.9 The SCS needs to provide an appropriate HCI for all elements of the SCS that is easy to interpret and use. The HCIs should have the following attributes:

- Not compromise the safe running of the tram system at any time;
- Provide that all HCIs used for the same purpose are identical;
- Display indications and access control functions of auxiliary systems and services, including the following:
  - Operation of Passenger Help / PEHP System;
  - TLDSS status and alarms;
  - Public address announcements, volume level control and indications;
  - Auxiliary power supply status and alarms;
  - Intruder alarms;
  - Telecommunications subsystems status and alarms;
  - Ticket Vending Machine (TVM) alarm indications (where used);
  - CCTV;
  - Plant / equipment / services status indications and alarms;
  - Traction power system;
  - Emergency telephones;
  - Performance monitoring system;
  - Central data recording and storage;
  - Central time;
  - Security;

- Customer information display management;
- Telecommunications network(s) management; and
- Fire alarm system.

5.10 All HCI's should have the following design requirements and provisions:

- Similar equipment and procedures used for like functions;
- Similar functions in the same general physical location in each HCI;
- Frequently used equipment in convenient locations;
- Most frequently used procedures require the fewest, least extended actions possible;
- The amount of equipment and variety of procedures at a HCI is minimised;
- Voice communication interfaces integrated such that OCR staff need not switch between more than two devices to interact with the several parties with whom they may need to maintain contact;
- Audio outputs have volume and tone controls;
- HCI physical dimensions are consistent with ergonomic limits in that they should be designed to accommodate the reach of a 5th percentile female and the size of a 95th percentile male;
- HCI components are modular to allow replacement of a failed unit within 30 minutes, and replacement should not require the shutdown of the functioning portion of the console; and
- Space for writing and documentation storage.

5.11 All graphic displays should deploy the following:

- Distinct colours and display attributes (for example, flashing) should be used to draw attention to alarm or abnormal conditions;
- Consistent use of colours, geographic orientation, labels, display attributes, and object symbols; and
- Label and message contents in accordance with the agreed network nomenclature.

6 Supervision and Control System

Overview

6.1 The SCS provides the primary interface for project operations staff to safely and efficiently monitor and manage the project operations.

6.2 Whilst the SCS needs to provide the main HCIs, it is not expected that the SCS, and / or its subsystem(s) will carry undue safety integrity. Moreover, the expectation is that those certifiable items from other subsystems / certifiable elements which interact and / or interface with the SCS, (for example, traction power system, point controllers and indicators, highway traffic signal controllers etc.) have as part of their functionality and safety justification the ability to successfully perform the necessary checks and balances prior to being exercised upon a request from the SCS.

6.3 The SCS needs to comprise of a suitable suite of composite subsystems, some of which may be certifiable items, that individually and collectively allow the following:

- OCR staff will be able to:
  - Safely monitor and control the operation and maintenance of the network;
  - Monitor the security of tramstops, depots, substations and other locations where CCTV surveillance cameras are provided;
  - Hold clear, dependable and effective voice communication between with project operations staff, for example, with tram drivers and other authorised personnel; and
  - Clear and audible voice messages with passengers, and / or the public, at tramstops through the Public Address (PA) system;
- Timely and accurate dynamic information for tram arrivals at tramstops and the current state of the services through Passenger Information Displays (PIDs);
- Health and current status information of key elements of the network infrastructure to be communicated in real time and displayed in real time to the OCR Staff and other authorised personnel;
- The location of trams on the network to be monitored in real time and displayed in real time in the OCR;
- Real time monitoring and control of the traction power subsystem and the taking of isolations of the OLE, or ground borne equivalent, which can be operated and monitored from the OCR;
- The recording and storing of events and communications such that the network's performance measure outputs and the replay / reconstruction of incidents can be actioned; and
- The provision of housings, cabinets, equipment rooms and other buildings for equipment necessary to enable dependable operation of lineside communications equipment.

6.4 The SCS must have the ability to:

- Function in normal operating mode without operator intervention;
- Have the capability for performing orderly system start-up and shutdown as commanded by a system operator;
- Permit remote equipment to operate safely in an unattended mode; and

- Permit the central SCS equipment to continue operation in the event of a failure of remote equipment, and upon return to service of failed equipment, automatically resume normal monitoring and management of that equipment.

6.5 Should the SCS become completely inoperative, for any reason, the network should be able to continue to operate the services and execute the project operations safely.

Dependability

6.6 Although the SCS is service critical, but not necessarily safety critical, its design, implementation and maintenance needs to cater for appropriate levels of dependability and availability, which would typically include the following:

- All critical devices, remote input / output equipment, radio equipment, and microwave equipment would be powered from an uninterruptible power supply (UPS).
- Such UPS should be sized to carry the full load of the above equipment for at least four hours.
- The UPS charger should be:
  - Sized to carry the above load while recharging a completely discharged battery set; and
  - Able to recharge the batteries under these conditions in less than 12 hours.

6.7 A device should be considered critical if, when removing power to it, its performance will be degraded.

Software

6.8 The design and implementation of SCS software should include the following:

- Follow guidelines for software design and documentation as defined in IEEE 729[2]; and
- Conduct a software quality assurance program for software development consistent with practices as defined in IEEE 730[3].

6.9 The software should be easily definable and modifiable including the following:

- The overview display and HCI display contents can change as track, tramstops, and other devices, equipment are added; and
- HCI display devices can be changed.

6.10 The application software should comprise of the following:

- Written in an industry-standard high-level language;
- Built on a commercially prevalent or industry-standard operating system; and
- Be portable to higher capacity computer system configurations running that standard operating system.

2 IEEE 729: Standard Glossary of Software Engineering Terminology
3 IEEE 730: Software Quality Assurance Processes

6.11 Networking system software should satisfy the Open System Interconnect (OSI) requirements and / or utilise industry-standard physical level and link level communication protocols.

Central Equipment

6.12 Centrally located equipment should have the following attributes:

- When in normal operating mode, operate safely when unattended;
- Have sufficient redundant equipment to permit automatic switch-over so that no single failure will interrupt project operations for more than 30 seconds;
- Automatically detect equipment failures and provide corresponding failure indications;
- Where feasible, provide for on-line replacement of failed components, console devices, computers, peripheral devices and data communications interface equipment while it continues to operate safely;
- Be sized to enable the network to be safely and effectively managed under peak period operating conditions and have provisions for future expansion:
- Be capable of communicating and providing control and indication of all of the existing remote equipment;
- Be physically located and configured in such a way so as to provide for easy maintenance access; and
- Be provided with a UPS, with a minimum capacity of four hours, and a redundant source of AC power or provision for the connection of a mobile generator.

Remote Equipment

6.13 The remote equipment, the field portion of SCS (for example, Remote Interface Units (RIU), or direct interface points / ports of point controllers etc.), should have the following attributes:

- When in normal operating mode, will operate safely when unattended;
- Perform self-tests upon power up and on command from local test equipment and from OCC;
- Support remote initialisation and troubleshooting via the data communications network;
- Be of common design for all remote sites to provide easy and efficient interchange of modules;
- Capable of continued safe operations with the loss of communication to the OCC as a result of either communication equipment failures or central equipment failures;
- Modular in design to provide expansion of performance and capacity by adding subsystem modules. This should include the ability to add a minimum of 20% more input / output subsystem modules; and
- Supplied with hardware and software tools and documentation for reconfiguration and expansion.

Access and Security

6.14 The SCS must have the following attributes:

- Provide all authorised project operations staff with the facilities to electronically log on and off the SCS at their work stations, and that access rights to appropriate parts of the SCS are governed by log-on and password configuration and that these levels of access are appropriately registered and administered; and
- Ensure that all information necessary to control the project operations and the services safely is continuously displayed to OCR staff and other nominated project operations staff.

6.15 The integrity of controls and indications provided to OCR staff and other nominated project operations staff should be appropriate to the extent to which safety depends upon their correct operation under normal operating mode and foreseeable degraded modes.

Alarms and Alerts

General Requirements

6.16 Alarms / alerts received at the OCR should be filtered, grouped and prioritised with only those that require OCR Staff action being indicated on the operator's HCI in the OCR.

6.17 All alarms / alerts should be targeted to a particular user / group of users and have a nomenclature that is unambiguous and easy to comprehend by that user.

Alarms Presented in the OCR

6.18 Acknowledgement of alarms should be from an alarm list window, or on the object icon as displayed on the appropriate operator HCI(s).

6.19 The SSC should have the following attributes:

- Provide facilities for the reporting and logging of alarm conditions;
- Define alarms as a special class of events and record them in the event record;
- Provide four levels of alarms, each directed to the operator (and / or maintainer) with authority over the alarming equipment as detailed in Table 6.1 below.

6.20 HCI symbols associated with an alarm related to a piece of equipment should also give a visual indication of the alarm state. When the alarm is acknowledged, the symbol should give a visual indication of this change in state. Table 6.1 below provides a list of alarm level attributes.

6.21 Appropriate authorisation needs to be provided to the relevant project operations staff to annotate an alarm with explanatory text. This text should also be placed in the event log.

6.22 All alarm events should generate an alarm message that should be electronically logged and displayed.

Table 6.1: Alarm Level Attributes

Alarm Level	Attribute
URGENT	Must have a clear, distinctive and immediately recognisable audible tone and visual indication.
NON-URGENT	Should have a different distinctive audible tone and visual indication to urgent, warning and information alerts.
WARNING	Should have a different distinctive audible tone and visual indication to urgent, non-urgent and information alerts.
INFORMATION	Should have no audible tone, but should have a distinctive and recognisable visual indication.

6.23 Each alarm message should have the following functions:

- Identify the system that has generated it;
- Be assigned a priority level; and
- Include the date and time of occurrence, and its location and plant identity.

Alarms Presented in Equipment Room and to Maintenance Staff

6.24 All alarm events should generate an alarm message which should be electronically logged and displayed to the project operations staff maintainers.

6.25 Each alarm message should have the following functions:

- Identify the system that has generated it;
- Be assigned a priority level; and
- Include the date and time of occurrence, location and plant identity.

6.26 Alarms should be presented in a hierarchical manner and high priority alarms should generate an audible tone.

Supervision of Tram Movements

6.27 The primary purpose of the SCS is to enable the OCR staff to supervise and manage the movement of trams around the network in accordance with the timetable without collision with other trams, vehicles or objects and to prevent derailment at points and crossings. To support this, the following will need to form part of the SCS.

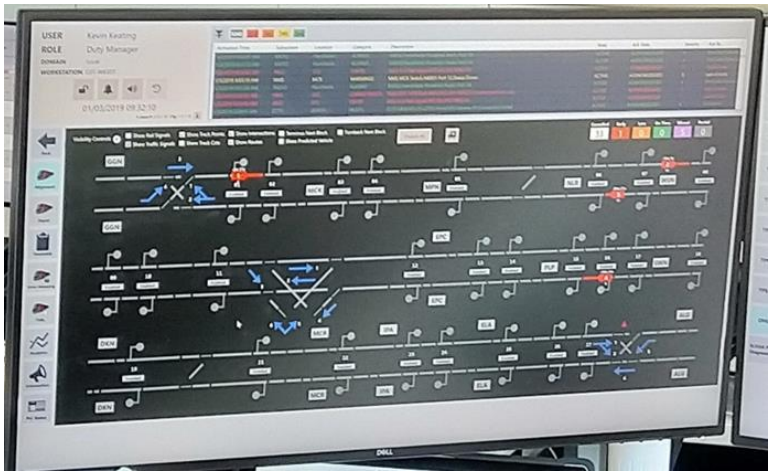
Tram Movement Operator HCI

6.28 There should be an adequately sized high-definition visual display with mouse and keyboard (or equivalent) for interaction with the TLDSS as illustrated in Figure 6.1. This should enable the following:

- The ability to view the:
  - Current state of the network;
  - Current position of trams;
  - Punctuality of trams on the network;

- View and acknowledge all alerts and alarms;
- Input a tram signal demand to a highway traffic signal-controlled junction, where needed, via the highway Urban Traffic Control (UTC) system;
- Allow the updating of the PIDs sub-system with an ad-hoc or pre-programmed suite of free text messages by clicking on the appropriate icon on the TLDS display; and
- Initiate a mobile voice call to a tram via the (Mobile Voice Communications) MVC.

Figure 6.1: Typical Visual Display



6.29 An operator HCI should present the following:

- A diagrammatic representation of the network, both as an overview display and a series of overlapping sectional displays, with each indicating the following as a minimum:
  - Last known / current position of each tram;
  - Run / route number of each tram;
  - Number of each tram;
  - Punctuality of each tram;
  - Driver staff identity for each tram;
  - Tram in service / out of service;
  - Tram destination; and
  - Status of each network signal and point indicator; and
- Show the status of the TLDSS dependent upon the indications fed back from the TLDSS remote equipment.

6.30 Two types of symbols should be used, which should be updated whenever a change in state is detected from the TLDS remote equipment. These are:

- Indication only; and
- Indication and control.

Tram Location and Detection Subsystem (TLDSS)

6.31 The primary purpose of the TLDSS is to detect the position of trams on the network and communicate these positions to the OCR to facilitate effective management of the services and to set the correct tram route ahead of the tram.

Location and Detection of Trams on the Network

6.32 The TLDSS would provide a number of functions, which include the following:

- Tram identification;
- Tram position on the network (outside of depot) or on the entrance / exit berths within the depot confines;
- Monitoring of the services;
- Route setting;
- Processing of manual and automatic 'tram ready to start' and advance signal demands requests from trams;
- Storage of data from the times each tram arrives at and departs from all of the tramstops. This will be passed to the central data recorder to allow the daily performance of the system to be calculated by the Performance Monitoring System (PMS) as set out in Section 6.73 and 6.74; and
- Provision of 'demands' to:
  - Points controllers to permit trams to safely traverse points at tramway junctions;
  - Local traffic signal controller(s) to permit trams to safely traverse tram / road crossings; and;
  - Provide controlled entry to and exit from the depot berthing and maintenance facilities.

6.33 If TDLS information is updated, it should be instantly transmitted to the OCR.

6.34 Detection systems should be configured so that the failure of an individual detector does not compromise the safe operation of a road junction or pedestrian crossing.

6.35 Key locations where tram position, route setting and detection equipment would be provided include the following:

- At the approach to and exit from network / road junctions;
- Entry to and exit from the depot;
- At the approach to and at all tramstops; and
- At the approach to and exit from points and crossings.

6.36 Trackside equipment at each of the above locations should be connected to the network's Operational Data Telecommunication (ODT) subsystem

6.37 In the event that this ODT subsystem fails, the TLDSS equipment at each of these locations should continue to operate autonomously until connections are restored without OCR staff intervention.

Data Entry and Capture

6.38 The TLDSS that is supporting the performance measure and / or the management of project operations staff needs to collect in real time the following information from each tram for transmission to the OCC:

- Tram number;
- Tram run number;
- Tram destination;
- Driver staff identity number;
- Driver duty number; and
- Tram in service / out of service.

6.39 Typically, the driver of each tram would enter the details of journeys for the particular tram for their entire operating day into the tram on-board computer at the commencement of service. Any change to this data, for example, as the result of an incident affecting the service, should immediately and automatically update the TLDS.

6.40 The TLDS should provide the following:

- Display to the driver how early or late they are at each stop; and
- Allow the driver to:
  - Issue 'tram ready-to-start' commands at selected tramstops;
  - When their tram is on the approach to a diverging junction, to manually demand that the points move left or right by operating controls in the cab (if automatic routing is used then manual route calling is not required);
  - Provide data of tram positions such that the PID sub-system can be updated automatically in real-time; and
  - Pass the times at which each tram arrives and leaves each tramstop to the PMS, so that the PMS can calculate the operational performance of the network and the services according to specified algorithms.

Route Setting

6.41 Point controllers should typically command powered point machines to be activated when valid data is received from an approaching tram. Such route setting functionality is best performed by the local point controller, being suitably protected from abuse, and not rely on communication between the remote location and the OCR

6.42 Under normal operating conditions, if each driving position of a tram is separately identified for route calling and route releasing, then suitable arrangements need to be provided to ensure only one driving position is active at any one time.

6.43 Where automatic route setting is required, the TLDS should automatically call for the setting of power points at junctions for the required route in advance of the tram approaching the junction.

6.44 Once the points have been confirmed as being correctly set by the point controller or point control subsystem, an indication of such should be given to the tram driver via a point indicator and to the OCR via the supervision of tram movements HCI.

Road Traffic Signalling Interface

6.45 Where there is a tramstop on the approach to a signalled installation, then the TLDS needs to detect a 'ready-to-start' signal operated by the driver of the tram.

6.46 The tram signals at signalled junctions should be driven from the local road traffic controller.

6.47 The tram detectors at all signalled road junctions should be directly connected to the local road junction traffic controller.

6.48 At diverging tram junctions, a tram signal may be capable of displaying different proceed aspects for the different routes if these are signalled separately. In such cases, the TLDS should decode the tram destination information and post the appropriate direction request to the road traffic signal controller as well as the point controller.

6.49 Examples of failure scenarios are provided below:

- Any one tram detector may cause some loss of tram priority but should still allow the tram proceed signal to be given with regards to tram demands;
- A detector needs to be detected and reported to the OCR via Operator's HCI; and
- TLDS equipment at any signal-controlled junction should initiate the immediate operation of the junction into a predetermined (adjustable) priority cycle sequence, with all such failures monitored, reported and logged to the OCR via Operator's HCI.

6.50 The TLDS / UTC system interface should:

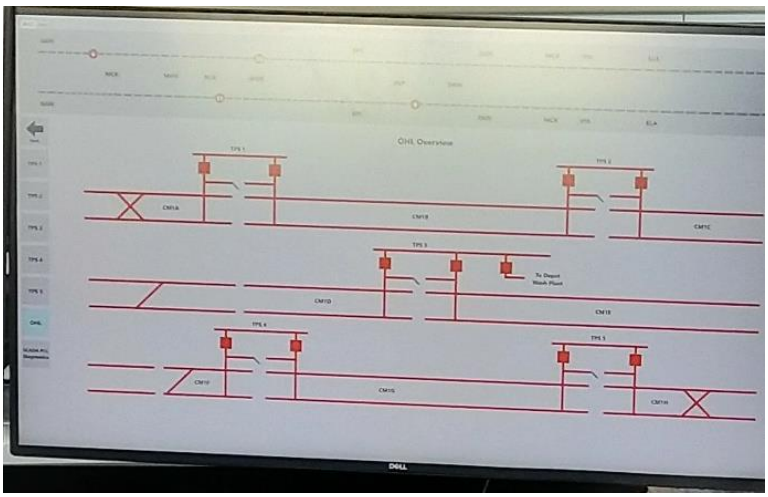
- Implement an agreed tram priority at each signal-controlled junction, as defined in the network's junction operating principles; and
- Incorporate the facility for the initiation of a 'tram proceed' signal in the event of either tram detection failure or local UTC System interface failure.

6.51 A foreseeable single point of failure should not cause a tram to be presented with a tram stop signal on the street that causes the tram to stop for more than 5 minutes.

Supervision of Traction Supply

6.52 The primary purpose is to enable the OCR Staff to supervise and control the supply and isolation of electricity to the traction power and / or auxiliary power distribution network either as a planned or emergency measure. See illustration of a typical display in Figure 6.2.

Figure 6.2: Typical Traction Power Visual Display



Traction Power Operator HCI

6.53 The HCI for the supervision of traction power should be provided by the same displays, mouse and keyboard, or equivalent that are used for the supervision of tram movements operator HCI.

6.54 Arrangements for the supervision and control of the traction power supply should be such that under all normal or failure conditions of the system, an emergency discharge of that supply at a particular location can be met within the response time required by the emergency services.

6.55 Sufficient information should be permanently displayed, or be readily and immediately available for display on the OCR operators' HCI, such that the operator is able to undertake the following:

- Relate, with sufficient accuracy, the electrical distribution system to the geography of the network; and
- Make safe the area affected by an incident in terms of network operation and electrical supply.

6.56 From the HCI, the operator should be able to activate the following:

- Isolate and earth any section of the traction power system by making a minimal number of mouse clicks, or equivalent, from the traction power HCI power diagram;
- Remotely control motorised isolators;
- Open individual circuit breakers by making no more than one or two mouse clicks, or equivalent; and
- Close of an individual circuit breaker or isolator to render the equipment live by no less than three mouse clicks in different places on the traction power HCI.

6.57 Authorised project operations staff should be able to select the traction power HCI from an appropriate menu screen or shortcut command, to be able to:

- Fully command and monitor the traction power sub-system; and
- Receive and acknowledge indications of restricted alarms sets from remotely located traction power and OLE equipment.

Picture Layouts

6.58 A minimum of two picture types should be provided to display traction information, as outlined below:

- Traction overview: this needs to provide circuit breaker indications, status of the supply only, and a general substation alarm indication; and
- Traction detailed pictures which include full control, indication and alarm status of the appropriate traction substations.

6.59 Two types of symbols would be typically used in picture layouts. They would be updated whenever a change is detected from the remote traction substations as the following:

- Indication only; and
- Indication and control.

6.60 Traction substation indications should typically be provided for the following;

- Breaker status;
- Substation local control;
- Traction equipment alarms;
- Rectifier breaker alarms;
- Track breaker alarms;
- Transformer alarms;
- Rectifier alarms;
- Emergency alarms / trips etc.; and
- Substation room fire / intruder alarms.

6.61 At all times, the current status of the traction power system, as determined from inputs received by the SCS should be available to be displayed to the OCR staff in real-time.

6.62 Display screens for the electrical supply systems that are capable of showing the locations of feeding points, and the actual position and status of circuit-breakers and section isolators should be provided.

6.63 The HCI should clearly show the actual position or status of all switches, isolators, circuit breakers and other devices controlling the power supply at all times.

6.64 When the HCI operator initiates a sequence of switching operations, the progress and completion must be indicated to them via the traction power HCI. Should any operation in this sequence 'time out' or fail, a visual and audible alarm must be generated to the operator and the sequence be suspended by the system.

6.65 All events within the traction power system should be logged and be able to be retrieved for analysis.

6.66 The controls and indications provided for each substation should include, but not be limited to the following:

- Fire alarms;
- Equipment and location over temperature alarms;

- Equipment and location intruder alarms;
- Low voltage power supply fault indication;
- DC power fault indication (for example, output circuit failure, etc.);
- Over voltage trip alarms;
- Under voltage trip alarms;
- Line live;
- Line earthed;
- Stray current monitoring (if provided);
- Power data, volts and amps in real time;
- 'No-break' power supply status; and
- Battery and battery charger status.

Supervision of Remote Equipment

6.67 The OCR should be able to perform the following:

- Supervise all remote electrical and electronic equipment via indications received at the operator's HCI from such remote equipment through the ODT subsystem; and
- Control and exercise remote electrical and electronic equipment from the operator's HCI in accordance with the functional requirements for that item of equipment.

Operator HCI for Supervision of Remote Equipment

6.68 The HCI for the supervision of remote equipment should be provided by the same displays, mouse and keyboard that are used for the supervision of tram movements operator HCI.

6.69 OCR staff should be able to select the HCI for the supervision of remote equipment from an appropriate menu screen or shortcut command to access current status information of the electrical / electronic equipment located at the following locations:

- Tramstops, including P&R sites;
- The depot(s); and
- Trackside equipment cabinets

Supervision of Tramstop Equipment

6.70 At the Operator's HCI it should be possible with minimum workload on the operator to undertake the following:

- Enable announcements to be made by OCR staff through the PA system;
- Make a text message entry by way of easily and understandable graphical user interface with Windows-type entry screens and prompts;
- Display a selection of pre-recorded messages and / or free form text on individual or groups of platform information displays;
- Enable OCR staff to enter and send free text messages to PIDs;
- Enable OCR staff to control CCTV cameras on the network and view the images;

- Provide indication of filtered alarms sets from remotely located equipment and infrastructure;
- Automatically display the image of the location where it has been detected that a Passenger Help Point / PEHP has been activated; and
- Allow new viewing patterns to be created, amended and deleted as required by the OCR staff to suit individual operational circumstances.

Supervision of Depot Plant and Equipment

6.71 At the Operator's HCI it should be possible with minimum workload on the operator to:

- Enable OCR staff to control CCTV cameras around the depot and view the images;
- Provide indication of filtered alarms sets from depot equipment and infrastructure which should include as a minimum current status of the following:
  - Tram wash plant;
  - Tram sand plant;
  - Effluent disposal system;
  - Depot standby generator;
  - OLE within the depot tram maintenance workshop; and
  - Operate the security access system to the depot;
- Allow new viewing patters to be created, amended and deleted as required by the OCR staff to suit individual operational circumstances.

Supervision of Trackside Equipment

6.72 At the operator's HCI it should be possible with minimum workload on the operator to undertake the following:

- Initiate the following commands:
  - Heating points in the event of the thermostatic control failing;
  - Move points; and
  - Initiate a tram priority signal phase from a road traffic signal controller; and
- Provide indication of filtered alarms sets from remotely located equipment and infrastructure.

Performance Monitoring System (PMS)

6.73 The Performance Monitoring System is part of the SCS and records, logs, analyses and reports on the performance of the services, the project operations, and the network assets in accordance with the performance measures.

6.74 In supporting the provision of performance reports and analysis, the PMS should contain the following functionality:

- Can collate a large amount of data from the other electrical and / or electronic subsystems / devices in order to assist in the production of the overall performance reports;

- Collates the above information into reports that can be used in the network's performance reporting regime(s);
- Archives, on a daily basis, the performance data to a back-office machine in the equipment room in a predefined format which is suitable for subsequent analysis by non-technical staff;
- Provides electronic audit trails of all the operational and maintenance work carried out by all parties; and
- Is connected so that it is accessible to all designated users whether such users at the same site or work remotely.

7 Network Security and Surveillance

7.1 The network delivering the services and implementing project operations must be demostartably safe and secure.

7.2 It is important to distinguish between safety requirements and security requirements. Whilst it is good practice to apply certification processes to both of these aspects, demarcation between conditions that could result in harm, whether unintentional (safety) or intentional (security) should be made. This guidance focusses on security requirements.

7.3 The implementation works and project operations must provide adequate security for the network and the services, taking due cognisance of the perspective of all passengers and staff[4]. Such works need to be designed and implemented to naturally incorporate crime prevention through environmental design to minimise potential threats and vulnerabilities to the network, its passengers and staff, and maximise safety and security through engineering and design. It is good practice is to set out the methodologies for implementing and maintaining security measures in a NMP as detailed in Section 4 of this guidance.

7.4 As a minimum, such security measures would typically need to deal effectively with the following (in relation to staff and passengers):

- Violence including threats, stealing by fear or force etc.;
- Verbal and physical abuse;
- All classifications of antisocial behaviour;
- Criminal damage; and
- Fare evasion.

Preventitive Strategies

7.5 Acceptable security strategies would normally include the following (as far as practicable):

- Maximising the visibility of people;
- Providing adequate lighting ;
- Anti-graffiti measures;
- Appropriate landscaping and planting that maximises visibility;
- Minimising P&R access points;
- Elimination of structural hiding places;
- Not enclosing or using high sided stairwells, shelters and lifts;
- Provision of CCTV surveillance on trams and at tramstops;
- Provision of PEHPs on trams and tramstops; and
- Provision of public address facilities on trams and tramstops.

4 In relation to vulnerable persons, refer to LRG 8.0 Guidance in the Management of Vulnerable Persons and LRG 28.0 Accessibility Guidance

7.6 Appropriate security measures such as CCTV surveillance, lighting, PEHPs and PA system, would normally be applied to trams and network infrastructure, for example, at depot(s), tramstops, P&R sites and routes to and from the network.

Access to Electronic Systems

7.7 The works and the project operations should ensure the following:

- Authorised access to electronic systems is login and password controlled; and
- Authorised access to appropriate functions of the system and its sub-systems should be allocated and governed by the users' login and password.

7.8 In considering the needs of passengers and staff, the needs of the more vulerable need to be considered. For further guidance, refer to LRG 8.0 Guidance in the Management of Vulnerable Persons and LRG 28.0 Guidance on the Provision of Accessibility in Light Rail Systems.

Equipment Misuse

7.9 The works and the project operations would ensure that:

- Appropriate protection is provided to both centrally and remotely located equipment to counter unauthorised access and / or vandalism;
- Physical access to all secure tram mounted equipment, trackside and tramstop equipment cabinets / housings, depot and substation buildings, plant and equipment etc. is by means of a structured hierarchy key security system. This may take the form of key locks or an electronic locking device such as swipe cards; and
- All locks and keys (in whatever format) should comply with the network security locking system and project operations staff are provided with a graded and structured key security system as appropriate.

Supervision and Control System Role in Network Security

7.10 The OCC and SCS play vital roles in ensuring the security of the network both in relation to security of network assets as well as the security of passengers. The OCC provides the platform and facilities to monitor security to help prevent an incident arising, but also to deal with an incident should one arise. The SCS provides the technologies to support the OCC in these aspects and such technologies would typically include the following.

Closed Circuit Television (CCTV) Surveillance

7.11 As a minimum, a continuously operational CCTV system of appropriate quality, functionality and reliability would be provided. This would need to include functionality for providing high-quality night-time images as well as the following attributes:

- Rear facing cameras located on the external body of trams;
- Forward facing cameras located either inside the tram cabs or externally of tram cab carbody;
- Tramstop platforms, and access / egress routes;
- Entrances, exits, walking routes and parking areas of P&R sites;
- Electrical substations; and
- Depots.

7.12 The CCTV system would be monitored for defects by the SCS and / or onboard tram master systems, including the following:

- Reporting of regular self-diagnostic status checks performed by the CCTV cameras and image handling systems;
- Daily remote checks by OCR staff and / or tram drivers including, for example, pan, tilt, zoom and wiper facility; and
- Other standard defect reporting processes, including reports by the project operations staff, passengers, the promoter(s), and / or other authorised agencies able to access the CCTV system.

7.13 The CCTV surveillance system should be capable of transmitting and displaying digital images in real time (minimum rate of 30 frames per second per camera) from the remote camera location, including cameras in tram saloons, or intermediate point to the central display in the OCR and appropriate operator HCI via a suitable cabled or wireless ODT subsystem.

7.14 The CCTV subsystem would typically include the following equipment:

- Remote equipment integrated into trams, tramstop or other lineside equipment housings or substations;
- Centralised equipment in the OCC equipment rom;
- Centralised display and OCR staff HCI equipment in the OCR;
- Interface with the ODT subsystem;
- Suitably vandalism protected colour image CCTV cameras with full pan, tilt and zoom facilities; and
- Digital image recorders remotely or centrally located.

7.15 In addition to the above, the CCTV viewing system would normally cycle through a pre-defined list of camera images and carry this out over a pre-programmed time period.

7.16 CCTV cameras should be able to provide the following:

- Provide clear images of evidential quality under all weather and lighting conditions at the OCR for operational purposes and for recording for prosecution purposes;
- Be configured with a unique identifier;
- Provide pan, tilt and zoom facilities both automatically within pre-set limits and under manual control, and be programmed to zoom in on the TVM when an alarm is initiated; and
- Incorporate ‘no-dwell’ zones to ensure the privacy of adjacent buildings which should be suitably adjusted at the time of camera installation.

7.17 OCR Staff should have the facility to override automatic operation and control the cameras remotely.

Substation CCTV Requirements

7.18 At least one CCTV camera should be provided at each electrical substation to provide adequate surveillance of the following:

- Exterior of the substation building;
- Access to the interior of the substation building; and
- The substation site / compound.

Highway CCTV Requirements

7.19 The design, implementation and maintenance of any CCTV camera that is capable of viewing the highway land or any other public highway covered by the network should:

- Comply with a code of practice approved by the relevant Local Highway Authority(ies) and the police; and
- Provide a link between the CCTV cameras and the relevant UTC.

Tram CCTV Requirements

7.20 Further to the guidance provided above, all trams should be fitted with CCTV system which records digital images covering aspects:

- The whole of the saloon, with sufficient clarity to enable individuals to be identified for evidential purposes or to assist incident investigation; and
- The views ahead / back from the cabs.

Passenger Emergency Help Points (PEHPs)

7.21 Assuring confidence to passengers is a critical part of providing a successful service of which PEHPs form an integral part. They would be provided at key passenger interface locations and onboard trams.

7.22 To assist in providing a safe and secure environment for those using the network and the services, continuously operational PEHPs should be provided at each platform of all tramstops, at P&R sites and on all trams. The performance of PEHPs should be in accordance with the performance measures.

7.23 PEHPs would be monitored in real-time for defect by interfacing with the SCS including by monitoring and reporting the following:

- Regular self-diagnostic status checks performed by the PEHPs and the call handling systems;
- Automated polling by the central server after a maximum period elapsed since last communication;
- Daily check by manual activation; and
- Other standard defect reporting processes as required, including reports by the project operations staff, passengers, or the promoter(s).

7.24 Minimum PEHP provision at tramstops and P&R sites would typically include the following:

- Minimum of one PEHP on each Tramstop platform; and
- One PEHP for each zone of each of a P&R site.

7.25 PEHPs on trams would be located in the saloon area, at every door area, and at the disabled passengers' area. These devices need to allow communication with the driver, and / or OCR staff, with the location of the active device indicated on HCIs of both tram driver and OCR Staff.

7.26 PEHPs should have the following attributes:

- provide two-way (duplex) audio communication between:
  - The PEHP user located on the tramstop platform and the operator located at the OCR;
  - The PEHP user located on a tram and the tram-driver or the operator located at the OCR; and
- Be sited in consistent position at all tramstops, P&R sites and on trams, so that they are visible by the CCTV cameras at these locations; and
- Automatically initiate immediate audio recording of the communication between the PEHP user and the OCR staff, or tram driver for PEHPs on trams as well as simultaneous video recording, with such video images from the respective CCTV camera immediately displayed and alerted to the OCR staff.

7.27 Such notifications and displays would ideally be distributed to the central overview display and HCI of the operator supervising the location where the PEHP is activated.

7.28 When a PEHP is activated, it would typically be required to initiate the following:

- An alarm raised and displayed on the appropriate OCR workstation(s);
- Movement of the appropriate CCTV camera to view the device and caller;
- Give priority transmission, recording and viewing of such CCTV images to the appropriate OCR workstation(s), and / or tram-driver, until such time as the OCR staff or tram-driver concludes the audio conversation with the user of the PEHP; and
- The activated CCTV camera to automatically return to its normal scanning sequence when the OCR staff, or tram driver, concludes the audio conversation with the user of the PEHP unless the camera is in manual control by the OCR staff.

7.29 Each PEHP should be clearly visible, signed and mounted in a manner that minimises its vulnerability to vandalism.

Public Address (PA) System

7.30 Besides use in normal project operations for announcing the services to passengers, the PA system can act as a primary security system. In this mode, it serves as a means of providing important audible messages and instructions.

7.31 PA system would be situated in the same locations as PEHPs. Each PA system should be clearly visible and signed, and mounted in a manner that minimises its vulnerability to vandalism.

7.32 PA system will interface with the SCS and alert OCR staff to a PA system activation and open audio dialogue. This would normally be to the HCI of the operator supervising that locality.

7.33 PA system on board tramsshould raise an alert on the tram-driver's HCI and open audio dialogue when activated,.

7.34 Tramstop PA system speakers could be incorporated into tramstop name and other signage on and / or within each shelter panelling.

7.35 The PA system should permit OCR staff to make direct announcements to any zone or groups of zones and have the ability to turn off zones. To facilitate this, the following should be the minimum zoning configurations:

- Each tramstop platform should constitute a zone and should be independent of other zones at the same tramstop; and
- P&R sites should be considered as a single zone for public address purposes.

8 Telecommunications

8.1 To support the SCS in safely delivering the project operations and the services in accordance with the performance measures, a telecommunications subsystem needs to be provided. This must provide voice and data means of ensuring that the OCC can communicate with all authorised project operations staff, and remotely located electrical or electronic equipment.

Voice Communications

8.2 Voice communications for use in the network would typically comprise a secure radio or other mobile telecommunications bearer, and standard telephony.

Mobile Voice Communication (MVC)

8.3 Safe and secure two-way mobile voice communication between the OCR and project operations staff located on trams, and / or carrying project operations on the network must be provided. This would include, but not be limited to the following:

- Drivers and project operations staff on board individual trams, groups of trams and / or all trams;
- Drivers and project operations staff of road and other support vehicles; and
- Individually or in groups with other mobile project operations staff using hand portable equipment on the network and / or in the depot.

8.4 Reliable mobile voice communications should be continuous and free from interference throughout the network, and to all areas used by project operations staff in the course of their duty, so there is an effective and reliable communications network system in place to ensure both general and emegency communication..

8.5 The MVC would have the following functions:

- Allow selective calling and identification of individual trams such that instructions that are critical to safe operation can be communicated effectively;
- Incorporate the facility for each of the emergency services and project operations staff to use their own portable MVC devices within their own command structure;
- Voice communications between the OCR and a tram driver(s) should be kept separate from those between the tram driver and the passengers on the tram;
- All radio calls need to be capable of being made and received via the MVC HCI;
- Nomenclature for tram radio call signs should be the same as the tram number;
- Be capable of group and broadcast calls with normal or emergency priority; and
- Have all voice communications recorded by the central voice recorder.

8.6 All outstation radios / MVC mobile devices should be equipped with an emergency call facility. When such an emergency call is received at the OCR, a distinct audible and visual alarm should appear on the operator's HCI.

Standards and Frequencies

8.7 The MVC should operate within allocated frequencies administered by OfCom, with any operating licences and consents obtained from OfCom and / or any other relevant / appropriate authorities, for example, the Civil Aviation Authority (CAA).

Operator Interface

8.8 The main operator interface with the MVC should be provided by the following:

- Workstations installed in the OCR for OCR staff;
- Tram mounted mobiles for tram crews; and
- Road vehicle mounted mobiles and hand portable equipment for other mobile staff.

8.9 The primary means of initiating radio calls to individual trams from the OCR staff should be achieved by mouse click(s) or equivalent using the relevant tram icon represented on the supervision of tram movement HCI.

8.10 The attention of OCR staff to a tram making a radio call to the OCR should be achieved by appropriate graphical indication on both the supervision of tram movement and MVC HCIs accompanied by an audible alert.

8.11 All MVC communications would typically be via the OCR; through touch screen interface that permits the following:

- Initiation / receipt of radio calls to any / all tram(s) and other vehicles fitted with MVC equipment;
- Initiation / receipt of radio calls to any / all portable radio handsets;
- Audible and visual alarms for emergency radio calls received. Such alarms should be displayed so as to clearly differentiate between normal events and emergency events; and
- Use of short radio codes (refer to Table 8.1).

8.12 It should not be possible for an OCR member of staff to cancel an emergency call without answering it.

8.13 When OCR staff send a single voice message to all trams and request tram drivers to acknowledge receipt, the MVC should present a list of all trams and their message acknowledgement status to the OCR staff via the MVC HCI.

8.14 To enable the OCR staff to identify any trams that have not acknowledged a voice call or broadcast sent from the OCR the status should be shown on the MVC HCI and coloured to identify:

- Trams that have acknowledged the message, in green;
- Trams that do not have active radios, in amber; and
- Trams that have not acknowledged the message in red.

Short Codes

8.15 The MVC should be able to send short codes to individual trams, groups of trams or to all trams, and configurable by the user's administrator.

8.16 Short codes could typically include those listed in Table 8.1 below.

Table 8.1: MVC Short Codes

Status Message	Status Meaning	Control to Tram	Tram to Control
CHANGE	Change Active Unit		✓
ACK MESS	Status Message Acknowledge		✓
ACK CALL	Group Voice Call Acknowledge		✓
###-DEP	Departure from Departure Points, where ### is the three-letter code for each departure tramstop		✓
DELAY	Delay to Report		✓
FAULT	Defect to Report		✓
NEWCREW	Crew Change Complete		✓
HELP	Police Required		✓ (See notes below)
EXIT	Depot Exit Request		✓
ENTRY	Depot Entry Request		✓
RELIEF	Crew Relief Request		✓
XO-DONE	Crossover / Turnback Complete		✓
STABLED	Tram Stabled		✓
CREWGONE	Driver Leaving Tram – shall report back		✓
ALL-STOP	Stop Immediately	✓	
STOPNEXT	Wait Next Stop	✓	
FIREMEN	Beware Fire Engines	✓	
FIREGONE	Fire Engines Clear	✓	

Notes: -

1 The HELP code should also be able to be sent from the hand portable and from the road vehicle radios.
2 The emergency call functionality should also require the use of short codes.
3 There should be at least 50% spare capacity for additional codes.

Base Stations

8.17 All base station antennas should be fitted with adequate surge protection measures.

8.18 All masts required to support base station equipment should be capable of withstanding all known wind loading and fitted with anti-climb protection.

Road Vehicle Mobile Radio Equipment

8.19 The Opsco will typically operate road vehicles requiring MVC mobile equipment. Typically, the road vehicles would be equipped with the following:

- Mobile transceiver;
- Cable harness, feeder and antenna;
- Display, keypad, speaker and microphone; and
- Necessary power supplies for 12-24V DC operations.

8.20 Such equipment should be equipped with a keypad, or equivalent, and alphanumeric display unit and be capable of displaying and storing short data messages.

8.21 Road vehicle mobiles should translate status codes into meaningful textural messages and be equipped with an emergency call facility.

Hand-Held Mobile Radio Equipment

8.22 Mobile project operations staff would typically need to be provided with hand portable mobile MVC equipment. Such equipment would include the following:

- Hand-held radios with battery including spare battery / batteries; and
- Sufficient charging racks to ensure availability of fully charged radios.

8.23 All hand-held MVC devices should be:

- Weatherproof and suitable for continuous use on or about the person in the outdoor environment;
- Equipped with a keypad, or equivalent, and alphanumeric display unit and be capable of displaying and storing short data messages; and
- Equipped with an emergency call facility.

Telephony Voice Communications

Essential Voice Communications

8.24 Telephone links would normally be provided between the OCRs of local emergency services and the network OCR. As such, the telephony communications subsystem would likely have dedicated direct lines to the following:

- Fire brigade OCR;
- Police OCC;
- Bus partnership OCR(s);
- City centre / UTC CCTV control centre; and
- Relevant railway authority signal box (where relevant).

8.25 All incoming calls from emergency services must be brought to the attention of the OCR staff, via messages, audible alarms and / or indicators presented of the operator's HCI.

General Telephony Requirements

8.26 The network would be provided with a telephony subsystem that provides two-way voice communications between project operations staff at fixed locations throughout the network and be integrated.

8.27 All voice communications and messages critical to safe project operations should be recorded on the central data recording system.

8.28 All OCR communications between OCR staff should also be recorded for at least thirty-one days.

8.29 The telephony subsystem would typically comprise the following:

- A central private automatic branch exchange, or equivalent, with interfaces to the following:
  - Public switched telephone network;
  - Depot extensions;
  - Passenger Help Points / PEHP;
  - PA system;
  - Substations; and
  - MVC subsystem;
- Call recording equipment;
- OCR HCI for the integrated telephony and radio services; and
- Call logging and maintenance facilities.

8.30 The telephony subsystem should have the following attributes:

- Include all private automatic branch exchange equipment, all necessary interfaces, configuration of the system elements, the connecting cables and management and diagnostic facilities;
- Provide maintenance and administrative staff within the depot and substations with telephone communications facilities appropriate to their needs;
- Provide voice communication with all internal network organisation members and external parties but not with trams;
- Be designed to operate in an integrated manner; and
- Use the ODT subsystem for call routing to remote locations, for example, tramstops and traction power substations.

8.31 The telephony subsystem should be equipped with a maintainers' workstation for network management and diagnostics. As such it should provide and allow the following:

- Display of system status and alarms;
- Download of call and system logs to removable media;
- Configuration of the telephony subsystem;
- Management of subscribers;
- Provision for updating system software; and
- Reporting of real time status and alarms to external equipment.

Operator Interface

8.32 The main operator interface with the telephony subsystem would be an integrated HCI at each operator workstation designed to carry out control functions in an ergonomically efficient manner.

Data Communications

8.33 All data communications are concerned with the transmitting and receiving of data between two or more items of remote equipment and / or items of remote equipment and the OCC.

Operational Data Communications

8.34 A high bandwidth fault tolerant telecommunications transmission subsystem would communicate dependably and accurately with remotely located equipment including CCTV cameras.

8.35 An ODT subsystem would support all two-way voice and short code communications between various locations on the network with high dependability and availability, but with low latency.

8.36 Communication between two or more items of trackside / remote equipment and from trackside / remote equipment to the OCR should be by such means that permits minimal trackside cabling and an acceptable level of system integrity.

8.37 An integrated communications infrastructure needs to be suitable for the satisfactory transfer of all data, telephone and other signals required for controlling, monitoring and communicating with equipment distributed throughout the network.

8.38 The ODT subsystem would have the following attributes:

- Use a fibre optic transmission and / or wireless transmission system that meets the PRAMS[5] requirements of the network;
- Have automatic diverse routing to allow the continued operation of the network without undue loss of data following the break in a single transmission path;
- Incorporate low transmission latency such that it does not contribute any appreciable delay to any voice or data applications;
- Have sufficient bandwidth to convey all voice and data, including video / digital images, without contention;
- Have an expansion capability to allow for system growth or to enable further interfaces to be added or an increase in the bandwidth requirements of existing applications or known future enhancements of the network;
- Include all master and outstation node equipment, interface cards, configuration of the system elements, the connecting cables and management and diagnostic facilities;
- Be configured such that in the event of single failure there should be no loss of data and no requirement for excessive actions on the part of the OCR staff; and
- Be configured so as to provide automatic re-routing in the event of failures such that any loss of facility is confined to that given locality and does not affect the operation of the transmission system and facilities at any other location.

5 Plans, Relationships, Agreement, and Maintenance

9 Implications for Alternative / New technologies

Communications

9.1 In recent years there has been growth in IT and telecommunications systems moving the processing, transactions and storage to cloud-based platforms. Where such technologies are deployed on tramway networks, this could have implications upon safety and security.

9.2 Current systems provide mobile voice communications mainly effected by an operational radio system with frequencies and licences obtained from Ofcom. This provides a secure private network and gives high confidence that operational calls between the OCC and tram-drivers and / or mobile project operations staff can be made safely, dependably and securely. These solutions require significant hard-wiring to connect base station infrastructure.

9.3 Similarly, data transmission is largely achieved through the installation of a fibre-optic bearer network connecting tramstop equipment, remote electronic equipment and electrical substations to the OCC. This also involves significant construction works and capital costs to lay the fibre cables.

9.4 When developing new networks, there may be an opportunity for cloud-based technologies in terms of economics and ongoing maintenance perspectives.However, there are the following implications when this is being consideried:

- Safety;
- Security and integrity; and
- Commercial benefits.

9.5 It is unlikely that the contracting parties of a network have all of the facilities and resources to implement and manage a cloud-based communications bearer system that is readily available, or the ability to undertake the transactional processing in house. Therefore, unless the contracting parties include an IT partner, communication would need to be outsourced as a managed service, which is normal practice outside of the transport sector, for example, banks, retail and supply-chain organisations.

9.6 Although such cloud-based communications can be appropriate from both economic and logistics perspectives, the following issues also need to be confirmed:

- Can relevant and binding contractual arrangement be put in place with such cloud-based technology partners and data transaction companies that enable the network and project operations to meet the specified performance measures?
- Can such outsourced solutions delivery the system integrity necessary to maintain the safety and security of the network and project operations? and
- Does the reliance on such outsourcing compromise the safety justification for the network and project operations?

9.7 From a safety and security aspect alone, designing, implementing and maintaining such a technology shift, would most certainly require the safety and security analysis and assessment sufficiently contained with a ROGS Safety Verification Scheme process.

Traction and Ancilliary Power

9.8 The second area where alternative and / or new technologies could impact network supervision and how SCSs are designed and implemented relating to traction power and electrical power distribution systems is the deployment of 'self-powered' trams. Two alternative technologies here are considered below.

Hydrogen Powered Trams

9.9 There is emerging vehicle technology in relation to the utilising hydrogen fuel cells within their powertrains. This would mean that networks would no longer require large traction power substations or route coverage with OLE and as such, could be attractive to promoters. Hydrogen fuelling facilities would need to be provided at the depots and / or some strategic tramstop locations.

9.10 Such a move would impact the SCS in the following two ways:

- Assessment would need to be made as to whether any electronic and / or data monitoring of hydrogen fuelling facilities is required; and
- All the high integrity safety checks and balances with supervising the current 750V DC, or similar, electrification and power infrastructure, including taken isolations and possession would be removed. However, there would still be the need for the SCS to be able to supervise, manage and / or isolate lower voltage power distribution to tramstops and remote equipment.

Battery Powered Trams

9.11 There is emerging vehicle technology in relation to the switch to electric vehicles. Some such technologies like automotive require physical plugging in of the tram at a charging point, for example, charging to overhead cables at tramstops or wireless charging.

9.12 This technology uses high-capacity batteries or energy stores which can reduce or even in some cases remove the requirement for 750V DC or similar electrification and power infrastructure.

9.13 This technology would have the following impacts and implications on the SCS:

- Physical charging systems may need the SSC to monitor their current state and energy capacity;
- Tramstop overhead charging systems would require reduced levels of supervision and management as current electrification and power distribution systems; and
- Wireless charging systems would most likely need to have their current state and associated renewable energy store capacity monitored.