LRSSB - LRG - 30.0

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Safety and Standards Board

Depot Control Centre Guidance

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DESCRIPTION:

THIS DOCUMENT PROVIDES DESIGN PRINCIPLES AND GUIDANCE ON THE DEVELOPMENT, DESIGN AND IMPLEMENTATION OF DEPOTS INCLUDING THE OPERATIONS CONTROL CENTRE (OCC).

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 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 31.0 Network Supervision Management Principles Guidance (LRSSB)
LRG 32.0 Testing and Commissioning Guidance (LRSSB)

RELATED TRAINING COURSES:	**RELATED LEGISLATION:**
N/A	Health and Safety at Work Act etc. 1974 Railways and Other Guided Transport Systems (Safety) (ROGS) 2006

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DEPOT CONTROL CENTRE GUIDANCE

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TERMS AND ABBREVIATIONS

Table A – Terms

Term	Definition
Central Equipment Room	The location at the depot where all centralised electrical and electronic equipment necessary for the project operations is located.
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.
Distribution Network Operator	Third Party responsible for providing incoming electricity supplies.
Network	The existing system as extended by the carrying out of the works including the 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, Park and Ride 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.
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.
Performance Measures	All measures, indicators and output requirements designated to successfully deliver the services and / or project operations.
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.
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 rail vehicles used for project operations.

Table B – Abbreviations

Abbreviation	Definition
BS	British Standard
°C	Celsius (degrees)
CCTV	Closed Circuit Television
CER	Central Equipment Room
CIBSE	Chartered Institution of Building Services Engineers
DNO	Distribution Network Operator
EU	European Union
HCI	Human Computer Interface
HGV	Heavy Goods Vehicle
Hz	Hertz
IT	Information Technology
kV	Kilovolt
LED	Light Emitting Diode
LRSSB	Light Rail Safety and Standards Board
Lux	SI unit of illuminance
m	Metre
OCC	Operations Control Centre
OCR	Operations Control Room
OLE	Overhead Line Equipment
OLED	Organic Light Emitting Diode
ROGS	The Railways and Other Guided Transport Systems (Safety) Regulations 2006
SMS	Safety Management System
TLDS	Tram Location and Detection System
TPG	Tramway Principles and Guidance
UK	United Kingdom
V	Volt(s)
VAC	Voltage Alternating Current

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 design principles and guidance on the development, design and implementation of depots including operations control centres (OCC) 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 tramway and is intended to give guidance and advice to those involved in the development, design and implementation of depots.

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

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

- LRG 29.0 Guidance on Human Factors in Operations Control Centres;
- LRG 31.0 Network Supervision and Management Guidance
- LRG 32.0 Testing and Commissioning Guidance; and
- Operations and maintenance requirements / guidance

2. Scope

2.1. This document provides high-level guidance in relation to the design, implementation and operational considerations of a tramway depot in order to achieve an optimised and holistic integrated systems solution.

2.2. As such, the scope of this guidance provides for:

- The design of new and / or extensions to existing depots; and
- Understanding the relationships between technical design in relation to the following:
  - Operational planning / modelling;
  - How the network and its assets are operated and managed; and
  - Environmental and sustainability commitments and considerations.

2.3. This guidance assumes the development, design and implementation of the depot is to current-state-of-the-art standards. However, Section 0 recognises that alternative technology is becoming available and as such, describes the impact of adopting such approaches in comparison to current technology.

2.4. This document does not provide exact details, dimensions, quantities etc. relating to depots as these will need to be applied on a scheme specific basis. However, elements are suggested as a guide based on best practice.

3. Depot Overview

3.1. A network needs a depot (or more than one if a larger system) to undertake vehicle maintenance and where trams are stabled when they are not in use. If more than one depot is required for the capacity of the network's vehicle fleet, then a main depot will usually also be the location for all of the network's supervision and management, control centre, infrastructure management, administration and welfare facilities.

3.2. This section provides high-level guidance on the purpose and functionality that needs to be implemented for a depot.

3.3. The holistic design and implementation of each and every depot should provide a high quality, cost-effective and sustainable facility which fulfils the functional requirements, project operations and also respects its surroundings.

3.4. Such holistic design and implementation should provide clearly delineated zoning both inside the depot building(s) and external facilities which, as a minimum, will need to identify and signpost the following (not exclusively):

- Safe walking and equipment transportation / movement routes;
- Areas where:
  - Protective clothing and / or equipment is required;
  - Public access is prohibited;
  - Road vehicles and / or pedestrian access is prohibited; and
  - Restricted working zones, for example: height, weight restrictions and working near OLE.

3.5. Activities within a depot include the following:

- Maintenance of the tram; and
- Management of the maintenance of the tramway infrastructure (in most cases).

3.6. The main depot would typically be the centralised location from which all project operations activities should be monitored and controlled. As such, it would normally be expected that the OCC of the tramway is located at a main depot.

3.7. The depot(s) should supply all the equipment, tools, buildings, vehicles and support services necessary to operate and maintain the tramway to the required levels of dependability, in accordance with associated relevant Standards and guidance, as well as the network's own specific performance measures.

3.8. When developing, designing and implementing a new tramway system, consideration should be given to extensions to the system at a future date and as such, the related extensions to the depot and its capacity and capabilities.

Core Functionality

3.9. Typically, the depot supports project operations through providing a central location and facilities, including the following:

- Where trams are serviced, cleaned and stabled;

- Where trams can be serviced, maintained and repaired in accordance with vehicle's maintenance specifications;
- Where project operations staff can sufficiently, efficiently and safely supervise the project operations on a day-to-day basis. Such project operations include the following:
  - Movement of trams and other rail vehicles over the network;
  - Scheduling and executing maintenance of the network;
  - Interaction with other undertakings and / or operators where the network shares infrastructure and / or interfaces; and
  - Interaction with third parties where their activities involve working on or near the network; and
- Where equipment, tools, materials for the maintenance of the network and the trams can be safely and securely stored.

4. Planning and Sustainability

Planning Consents

4.1. Any new depot(s) and / or modifications to existing depot(s) will be subject to planning consent(s) from the relevant planning authority, whether from a Local Planning Authority or through a Transport and Works Act Order[1] etc. As part of the change, each consent and condition will include:

- A need to be monitored and progress recorded via a consents register; and
- Constitute a defined requirement contained within the consents register with regular tracking of compliance and formal sign-off when undertakings and commitments are completed.

4.2. The development, design and implementation of any depot(s) will need to take due cognisance of national, regional and local planning policies and guidance. This includes the following (not exclusively):

- National Planning Policies, Statements and Policy Guidance;
- Regional Spatial Strategies; and
- Local Authority Plans.

Planning Authority Design Considerations

4.3. To achieve planning consents, key design considerations will need to be demonstrated. The overarching aim is to create an affordable, efficient, effective and maintainable architectural response to a very specific set of criteria. As such, a planning authority will usually look for depots to be designed to:

- Be a single entity rather than a series of separate components; and
- Fit within the existing or emerging townscape and or landscape structure, in particular demonstrating the following design aspects have been considered:
  - Reduce the need for screening and other mitigation measures. Where site conditions allow, visual impact may be mitigated by appropriate use of levels in the site relative to its surroundings, and the introduction of landscape screening; and
  - Achieve a high-quality design that fulfils the functional requirements and respects its surroundings, including the consideration of the following:
    - Size, height, footprint, orientation and position of structures and buildings;
    - Requirements for efficient tram movements especially entering and exiting the depot;
    - Land levels relative to and the links with the tram route;
    - Relative proportions of the site;
    - Accommodating of all operational facilities;
    - Access for pedestrians and vehicles, and security issues;
    - Massing of elements, materials and finishes (which should be chosen to complement the tram network and context);

1 https://www.legislation.gov.uk/ukpga/1992/42/contents

- Skyline impact;
- External storage areas;
- Views into and out of each site;
- Minimise impacts of noise and light when close to residential or other sensitive areas; and
- Flood risk.

4.4. An environmentally sustainable approach should be adopted taking consideration of the requirements of both the depot and the network, as well as commercial considerations, to achieve a reasonable balance between all factors. As such, potential environmentally sustainable opportunities exist including the following examples:

- Reducing material requirement and use of raw materials;
- Maximising the use of recycled or sustainably locally sourced materials;
- Selection of lower and / or renewable energy technologies;
- The use of local energy storage or generation such as the use of solar cells to power lighting and equipment and maximising opportunities for local supply; and
- Reduction in staff travel by car and materials transportation.

5. Site and Layout

5.1. The design of depots and their implementation must enable operation as a fully integrated facility, as well as enabling individual depot elements and functions to operate in isolation without adverse impact on another depot element or function.

5.2. Depot designs and implementations should provide as a minimum:

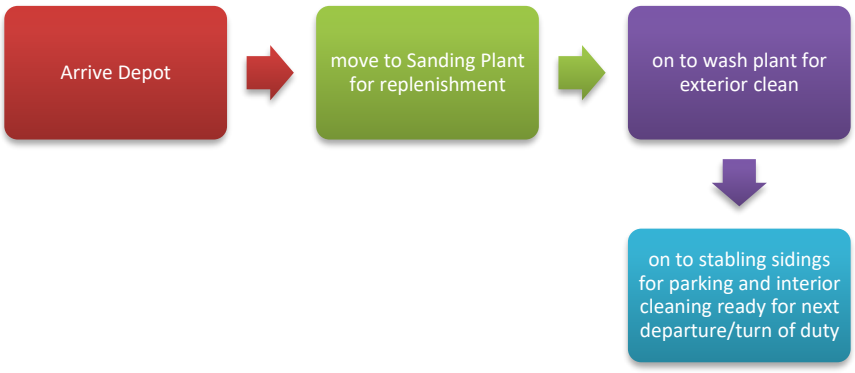
- Sufficient capacity;
- Adequate throughput and order of berthing;
- Segregation of functions and their interaction;
- Effective and efficient access and egress;
- Sufficient adequate security;
- Lighting;
- Parking; and
- Landscaping.

Tram Capacity and Throughput

5.3. The depot must be able to stable, clean and maintain an agreed number of trams, as derived and agreed from the operations planning and modelling workstream.

5.4. Layout of the main depot (and any subsidiary depots) where light maintenance is proposed, should facilitate the following primary movements and throughput when each and every tram enters the depot site. Figure 5.1 below shows this flow of typical movements of trams within a depot.

Figure 5.1: Typical Tram Movements in the Depot



Layout

Segregation of Functions

5.5. Whilst ensuring full integration of project operations, the layout of any depot should be zoned for the following functions and clear demarcation made between them:

- Workshop for tram maintenance;
- Stabling and sidings area;
- OCC; and

- Administration, management and welfare facilities.

5.6. Clearly marked safe access routes for pedestrian, equipment, and where appropriate vehicles, need to be provided within and between these zones.

5.7. A fully functional and safe depot layout must provide the following:

- Segregation of all rail and road vehicle movements as far as practicable;
- Provide for safe loaded fork lift truck movements to and from relevant parts of the site;
- Be orientated to group noise-generating activities as well as functionality and efficiency of use;
- Allow safe and easy road vehicle deliveries, including loading sand or detergent delivery into the sanding plant, taking into account the likely types of pressure discharge and of large deliveries to the inside stores etc.;
- Locate the lorry delivery point so that:
  - The lorry movements do not pass under any OLE;
  - Whilst at the delivery point, the tipping body, or any other part of the lorry will not come within 3m of any live OLE and such that it does not prevent road vehicle movements in the depot; and
- Ensure road vehicle access does not block adjacent highways or the depot internal road as part of the reason for such vehicles requiring access to the depot.

5.8. Acceptable boundary noise and lighting levels need to be agreed with the Local Planning Authority's Environmental Officer.

Accessibitility

5.9. The depot must be accessible by road and in close proximity to public transport links. This eases deliveries to the depot and provides sustainable travel to work choices for project operations staff.

Highway Access

5.10. A controlled road and footway access is required as illustrated in Figure 5.2. It needs to provide the following:

- The delivery of trams;
- Routine access by a heavy goods vehicles (HGVs) making deliveries; and
- Project operations staff accessing the depot by motor vehicle, cycle and on foot, etc.

5.11. Access control should be switchable between a reception or other nominated area for daytime use and the Operations Control Room (OCR) for out of office hours purposes.

5.12. The main highway and footway entrance should have separate entry and exit vehicle gates.

5.13. The vehicle gates should be capable of being opened and the pedestrian gate released from either the OCR, reception, or by a member of staff presenting a security card to a reader at the gate.

5.14. The pedestrian gate should close automatically and re-lock when it closes.

Figure 5.2: Typical Depot Access Road

5.15. The vehicle exit gate should open automatically when a vehicle approaches it from within the depot, and automatically re-lock once a vehicle has passed through, with a suitable time allowance for any driver of a following vehicle tailgating.

5.16. Intercoms are needed from each of the two entry gates (pedestrian and vehicle) to reception and OCR.

5.17. Two intercom positions can be provided on the same pole at the vehicle entry gate, one at convenient height for car drivers and one for HGV drivers, who should be able to use them whilst in the driving seats of their vehicles.

5.18. There should be one security card reader at the lower position at the vehicle entry gate and one with the intercom at the pedestrian gate.

5.19. Any equipment in centre of the road should be removable, if required, to allow tram delivery / movement by road if such deliveries are designed to be made through the same access.

Tram Access

5.20. Tram entry / exit locations should have manual security gates.

5.21. Tram entry / exit locations gateways should be fitted with a microwave or similar detector, which should sound a single brief distinct audible warning in the OCR whenever a person or larger object interrupts the beam.

Security

5.22. The perimeter of the depot site should be surrounded by secure fencing in a type and manner that integrates with the local environment.

5.23. The entire depot perimeter and the tram entrance junctions should be under CCTV surveillance and the images displayed real-time in the OCR.

5.24. A dedicated camera should be provided to view the depot highway access (refer to Highway Access section above). The images from this camera should be available on a

monitor in the depot reception area or other nominated workplace when access is being controlled from that location.

Lighting

5.25. The layout of the depot layout should minimise disturbance to neighbours.

5.26. Suitable lighting, for safe project operations staff and security needs to effectively illuminate the following:

- Access / departure / transfer tracks;
- Stabling and cleaning tracks;
- Tram delivery and test tracks;
- All walkways;
- Pedestrian and vehicle access gates and paths / roads;
- Car parks; and
- Storage areas.

5.27. Illumination should be in accordance with CIBSE, or equivalent, lighting guides with an average of 30 lux with a minimum illumination of 10 lux.

5.28. Lighting can be a mix of overhead, bollard or ground lighting to suit the operational and maintenance needs of that location.

Parking

5.29. Car parking provision should be made for the following:

- Service / project operations vehicles;
- Visitor vehicles; and
- Project operations staff vehicle requirements.

5.30. The number and provision of the number and type of parking spaces may be subject to any local planning or other requirements / restrictions, for example, a percentage of electric vehicle parking spaces and associated charging facilities etc.

5.31. Dimensions of parking spaces should be in accordance with the Disability Discrimination Act[2] Inclusive Mobility Guidance[3]. For additional guidance, refer to LRG 28.0 Guidance on the Provision of Accessibility in Light Rail Systems.

5.32. Appropriate cycle storage should also be provided.

2 https://www.legislation.gov.uk/ukpga/1995/50/contents

3 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1044542/inclusive-mobility-a-guide-to-best-practice-on-access-to-pedestrian-and-transport-infrastructure.pdf

6. External Facilities

Stabling and Cleaning

6.1. The network's vehicle fleet needs somewhere to park when not in use, and adequate space for servicing and cleaning between turns of duty. As a main depot and / or any satellite depots would provide this facility, depot design and implementation needs to cater for this by way of trackwork and other infrastructure to enable efficient performance of these functions. This section describes the key considerations and requirements necessary to do this.

6.2. The overall layout of the stabling and cleaning facilities should be operationally logical in the flow of tram vehicles, particularly when they are entering or leaving service (refer to Sections 5.3 and 5.4.) If space allows, it may be operationally to provide a bypass road past the washer / wash plant.

6.3. There should be adequate spatial provision, taking cognisance of operational needs, line of sight visual needs and safe walking / passage between berthed trams.

6.4. Logically laid out safe walking routes and access paths for pedestrians, and / or plant and equipment necessary for the stabling and cleaning function should be provided between each stabling track. Such access should be at least 1.0m and nearer 2.0m wide with service points to provide facilities for tram cleaning.

6.5. The length of walking routes from the depot building or other buildings to where tram crew or cleaners / maintainers need to access should be kept to the absolute minimum practicable.

6.6. Water and appropriate power need to be provided to each stabling berth.

Track and Formation

6.7. The depot track layout considered below is based on nominal 30m / 40m trams required to deliver the services and allows for shunting moves by two coupled trams.

6.8. The trackwork connecting the running line of the network to and from the depot needs to allow ease of access to trams entering or leaving the depot, and the operational throughout and flow of the project operations, as set out in Sections 5.3 and 5.4. As such, it should provide for the following:

- Two alternative routes to access the running line from each of the stabling and cleaning tracks and main workshop tracks;
- Adequate tram arrival / departure / transfer tracks, in order to prevent unnecessary blocking of depot sand, wash plant tracks and the running line; and
- Motorised points and crossings to optimise tram movement onto, off and around the depot's identified key / critical points.

6.9. The trackwork within the depot confines should provide access to the following:

- The main depot workshop;
- Sanding and washing plants;

- Stabling and cleaning tracks;
- Any sidings provided for rail maintenance vehicles and equipment;
- Tram / road delivery / removal track; and
- Test track (where provided).

6.10. The following elements need to be included in the layout of the trackwork:

- Trams are not required to be stabled over pointwork;
- Provide and accommodate safe working routes around the depot the site;
- Minimise the interface and interaction with road vehicles;
- Enable recovery of a failed tram from any of the stabling and cleaning tracks or access / departure / transfer tracks without undue disruption to the normal operation of the depot; and
- Facilitate isolated repairs or renewals without undue disruption to normal depot operations.

6.11. As far as reasonably practicable, all stabling and cleaning, delivery and main workshop tracks should be straight.

6.12. The depot track and stabling layout need to be robust in operation with single failures of vehicles or pointwork not causing a blockage of other tram movements. As such, single-ended stabling roads should be avoided.

6.13. The longitudinal gradient and cant (cross gradient) of all tracks within the depot should be as low as practicable, and if achievable, zero. However, this recognises terrain imperfection and cost of groundworks etc., so an absolute maximum longitudinal gradient is 0.2%.

6.14. To deal with risk of tram overrun through any terminating tracks, tram arresting devices should be provided at their terminating ends. Such arresting devices may be sliding friction, fixed type buffer stops or another arrangement.

6.15. To enable efficient tram movements around the depot without the need for tram drivers to leave their vehicles to operate point levers, all points within the depot should be truly trailable.

6.16. Safe walking routes should be provided to all points.

6.17. All points should include a non-slip surface / platform from which project operations staff stand to operate said points.

Drainage

6.18. Project operations within a depot will use water and chemicals. Therefore, depot design and implementation should be such that they provide drainage mechanisms which safely and effective discharge such outflows into appropriate receptors and prevent the site from flooding.

6.19. Drainage facilities provided should meet the requirements of the relevant accepted EU or BS Standards, industry good practice and relevant approval bodies. This should also take due cognisance of the functionality and throughput of the stabling and cleaning activities.

6.20. It is likely that drainage proposals will need to be approved by the relevant water utility, the Environment Agency, and the local highway authority. Any new flows into existing drains and the methods of connection need to be authorised by the local water authority, environmental planning authority, the local planning authority and local highway authority.

6.21. To reduce potential for contamination and blockage, separate surface water drainage should be provided for the removal of the following:

- Rainwater;
- Water used for 'domestic purposes';
- Water from the tram wash plant and bogie cleaning apron(s); and
- Water from fire protection systems and / or used for firefighting.

6.22. Surface water drainage needs to efficiently and effectively provide the following:

- Removal of rain water from the trackwork within the depot confines and the access / departure / transfer tracks; and
- Adequate protection against flood water entering the site and depot buildings.

6.23. Drainage facilities should include the following as appropriate:

- Storm sewer(s);
- Culverts;
- Retention ponds;
- Water quality ponds;
- Drains;
- Main sewers; and
- Open channels that serve the depot as part of the regional drainage system.

6.24. Drainage from trackwork should be interfaced with the road and civils drainage systems. Adequate drainage within the trackwork system should be provided such that the integrity of the trackwork remains secure.

6.25. Discharges from roads, car parks and other areas where there is potential for oil or fuel contamination should be routed using appropriate oil / fuel interception devices.

6.26. Particular attention should be paid to ensure that surface water drainage systems in the vicinity of traction substations and cable ducts are routed to avoid any risk of flooding of electrical equipment areas, point machine chambers etc., as well as the ducts themselves.

6.27. Adequate catch pits should be provided so that sand, grit or other debris does not block the drainage system and result in standing surface water.

6.28. Track drainage should feed into at least one catch pit before discharge into the local surface water drainage system and then onward via an oil-interceptor before final outfall.

Minor and Major Storm Drainage Facilities

6.29. Surface water drainage must be adequate to protect against minor and major storm events.

6.30. The minor storm drainage system should route runoff water from minor frequency storm events with minimum disruption to the depot and local environment, and may be conveyed in roadside gutters, gulleys, ditches and / or storm sewers.

6.31. The major storm drainage should be designed to convey runoff water from the major storm event to minimise health and life hazards, damage to structures and disruption to depot operations and / or delivery of the services.

External Storage

6.32. External storage facilities will need to be provided for large items and for a limited number and volumes of hazardous materials, for example, the following:

- Rail sections;
- Sleepers;
- OLE or lighting columns; and
- Detergents for wash plant.

6.33. Depot layout in this respect needs to allow for storage of such materials close to the functions / depot elements using them, whilst tempering such efficiency measures with the need not to have material strewn across the site and associated lack of control as to its safe storage.

7. Depot Buildings and Equipment

7.1. To optimise efficiency and communication between functions, the following would usually be contained within a single, appropriately insulated and constructed building or a series of closely interconnected modular buildings, as illustrated in Figure 7.1:

- The main tram workshop and other workshops;
- Stores and storage areas (for small items and large / heavy items);
- A secure room for cash;
- Management and administration;
- Operations and maintenance offices;
- Staff welfare facilities (support accommodation);
- Training and meeting facilities; and
- The OCC.

Figure 7.1: Typical Depot Building and Stabling

7.2. The building design should provide the following:

- Avoid noise being transmitted through the roof space between the workshop, upper floor offices, training areas, whilst retaining flexibility for future changes to layout;
- Maximise the amount of natural light to all rooms and spaces;
- Be orientated within the depot layout take consideration of solar gain and the view required from the OCR; and
- All finishes to be appropriate to the area and type of use within the building and in materials with a long life in a largely 24/7 environment.

7.3. Full heating and ventilation including air conditioning should be provided throughout the building with air conditioning to the operations control room, Central Equipment Room (CER) and training and meeting rooms. Heating and ventilation system(s) should be designed and implemented in line with sustainable considerations and as such, ground-source or air-source heat pump, or solar-thermal systems should be considered.

7.4. There needs to be adequate, sufficient and appropriate network cabling throughout the building for IT, telecommunications, electrical and electronic systems etc.

Tram Maintenance and Servicing Facilities

Maintenance Workshop Doors

7.5. As illustrated in Figure 7.2 below, the maintenance workshop tram doors need to allow quick, easy and safe passage of trams in and out of the maintenance workshop. As such, they would normally have the following attributes:

- Bi-parting, bi-folding doors with clear panels for through visibility; and
- Power-operated with push-button controls both inside and outside.

Figure 7.2: Typical Maintenance Workshop Doors

7.6. In the event of power failure or door operating equipment failure, it should be possible for one person to operate the doors to track being accessed manually.

7.7. It should be possible to change doors to manual mode from a ground level control device or switch.

7.8. A design of door which does not have the actuation equipment at the top, near the OLE, is strongly preferred.

7.9. As OLE will 'pass' through the doorways, it is essential that electrical safety is provided in their design, implementation and operation. Therefore, the following need to be ensured:

- The workshop doors must include an appropriate hole or insulated edge to accommodate the (live) OLE when they are closed; and
- The door leaves should be bonded and earthed so that should they inadvertently come into contact with the OLE, the fault resistance will be sufficiently low to ensure an immediate circuit breaker trip without damage to the doors, equipment or nearby humans.

Main Workshop

7.10. The tram maintenance workshop must be of sufficient capacity to maintain the size of tram fleet in accordance with the manufacturers' specifications and the network's Safety Management System (SMS).

Figure 7.3: Typical Main Workshop Area

7.11. Typically, the workshop should accommodate and provide for the following (not exclusively):

- A minimum of two tram maintenance tracks;
- A wheel lathe track and a further tram service road (can be combined if space and operational conditions permit);
- Sufficient maintenance pit space: the layout, cross-sections of the pit space should facilitate the optimisation of those aspects of tram maintenance for which inspection pits are required; and
- Traction power and OLE to all tracks.

7.12. So that project operations staff can work safely on trams, vehicles and / or the depot building close to the workshop's OLE, the traction power supply inside the workshop must include an appropriate earthing scheme and interlocking with relevant workshop equipment such as gantries, cranes etc. Such interlocking system must also clearly display status of the OLE (for example, live / dead) to project operations staff inside the workshop, including drivers of trams entering or leaving.

7.13. The workshop should also provide gantry structures, for access to the tram roof area from both sides. The number of such gantry structures directly correlate to the tram fleet size and maintenance cycles.

7.14. Under-track pits should also be provided that allow access to maintain the underside of the trams and should incorporate access and egress stairs, adequate lighting, drainage and power tool sockets.

7.15. The following suitable low voltage (LED) lighting should be provided by luminaries so they are:

- Placed so that light is given where required for work to take place, including when trams are present; and

- Easily accessible for maintenance (lamp change).

7.16. Similarly, LED task lighting should be provided and the methodology and apparatus used should either:

- Be from self-contained energy supply within the portable luminary; or
- Enable a safe system of work which deals with trips hazards from electrical cables where task lighting is connected to local electricity supplies.

Lifting Equipment

7.17. As illustrated in Figure 7.4 below, the workshop footprint needs to provide for fixed and portable lifting equipment to safely and efficiently enable the following functions:

- The lifting of a complete tram and / or parts of a complete tram;
- Unload and / or load a bogie from a lorry and transport it to / from the main workshop;
- Move a bogie from where it will be taken out from under the tram to anywhere it may be worked on; and
- Take any roof box off the roof of the tram. Any removal of roof boxes should be accomplished sideways over the overhead access platform and guard rails.

Figure 7.4: Example of Requirements for Workshop Footprint

7.18. Built-in jacking points (i.e., lifting under the tram bogies) should be provided to at least one of the tracks. It is preferable that built-in equipment be used, to leave an uninterrupted floor space when not in use, as well as avoiding handling jacks, trailing cables and minimising set-up time.

7.19. An overhead crane should be provided with the main workshop that is capable of the following:

- Loading or unloading a tram bogie from an HGV;
- Move a bogie from a position adjacent to a tram to the location where maintenance work is to be undertaken on the bogie; and

- Remove and lift sideways over the gantry access platforms any equipment mounted on the tram roof.

7.20. Stands to support a tram with any combination of bogies removed should be provided.

7.21. A drained pad is required with a water and power supply for a pressure washer, accessible to bogies by rail and also road so they can be cleaned off after being extracted and can have salt washed off after winter. The ideal location is outside the workshop but on the lifting road.

Accommodation Bogies

7.22. An appropriate number of accommodation bogies should be provided, to replace any of the tram bogies and allow a tram to be moved around the depot.

7.23. An additional requirement is for a bogie or equivalent to support the disconnected end of a split tram which must also be moveable at low speed.

Underfloor Wheel Lathe

7.24. As illustrated in Figure 7.5 below, an under-floor wheel lathe appropriate to the type of tram and running gear should be provided, and would be able to provide the following:

- Reprofile a complete tram in a single shift, with an appropriate definition of cut; and
- When placed in a central position on an appropriate workshop track, enable the workshop doors to be closed whilst the lathe is in operation.

Figure 7.5 Typical Under-floor Wheel Lathe

Paint Booth

7.25. An appropriate paint system / paint booth should be provided for panel and patch repairs. This should not involve the use of isocyanates or other hazardous materials.

Other Workshop Facilities

7.26. Provision should be made for the following within the main workshop, but the location should be safely away from the workshop tracks and capable of being separated from the main workshop area by closure of an industrial door:

- An adequate open area for flexible future use;
- Relevant Specialist tools, jigs and test equipment;
- Appropriate battery charging equipment for trams and fork lift truck and associated ventilation equipment;
- Hydraulic and electronic workshop facilities, including bespoke test benches;
- Fixed equipment, for the servicing and testing of hydraulic and electronic; and
- Special workshop facilities, including test benches should be provided, appropriate to the trams and other fixed equipment.

7.27. Appropriate networks of 110V and compressed air should also be provided.

7.28. Refer also to Section 9.7 which details the support and management facilities required for tram maintenance and servicing facilities.

Sand Plant

7.29. As illustrated in Figure 7.6 below, a sand dispensing plant should be provided to facilitate effective maintenance, turnaround of trams back into service. The capacity and location should correlate with depot throughput described in Section 5.3 and 5.4.

Figure 7.6: Typical Sand Plant

7.30. The requirements for the sand dispensing plant include the following:

- Need not be located in a building, but should be undercover to prevent sand dispersion into the outside and neighbouring environments, and provide adverse weather protection to project operations staff when engaged in sanding activities;
- Must have a minimum capacity of at least 30 tons, so that it will accept a full HGV load; and
- Must be capable of maintaining the physical condition of the sand in accordance with the sand's procurement specification when the sand is delivered to the tram sandboxes.

7.31. The sand dispensing plant delivery nozzles should be compatible with the sand filling inlets on the tram.

7.32. Delivery of sand from the sand dispensing plant to a tram should cease automatically when the tram's sandbox full capacity is reached.

7.33. The tram driver needs to be sure that it is safe to move off from the sand dispensing plant on completion of the sanding activity.

Wash Plant

7.34. Cleanliness of both tram interior and exterior finishes is required for customer satisfaction as well as for operational safety. As such, it should form a significant part of a network's performance measures. Most depots would therefore provide either or both of automated and / or portable wash plants and equipment as illustrated below in Figure 7.7.

Figure 7.7: Typical Wash Plant

7.35. The wash plant should be designed such that it will operate effectively at all temperatures 0°C and above and it must be effective in washing trams at an ambient temperature.

7.36. Facilities need to be provided to effectively wash the ends of the trams. Ideally, this would be incorporated within the capability and functionality of the choice of automated wash plant (as illustrated in Figure 7.7), or as a separate hand-wash facility. In the latter case, this would best be located in front of the wash plant and a tram length apart in the form of wash pads, with lances / rotary brushes supplying detergent solution from the wash, and drainage.

Stores

7.37. There needs to be an adequate stores facility for tram and infrastructure materials. Whether this is a combined storage facility or separate facilities for each discipline, the following requirements apply:

- Heavy / bulky materials required for tram maintenance, i.e. spare / accommodation bogies are stored undercover, close by and easily accessible to the main workshop;
- All materials are stored in a facility appropriate to the material manufacturers' storage specifications;
- All materials are stored in a manner / location whereby highest frequency / volume usage materials are the most easily accessible to the discipline using them; and

- Location of goods in the facility is easily accessible by delivery vehicles and do not interfere or interrupt depot operations and throughput.

8. Control Centre (Network Supervision and Control)

8.1. It is common practice to combine the supervision, control and management of the network at the same location as the main tram maintenance activity. This section describes the requirements and considerations relevant to the network's supervision and control that are relevant whether the control centre OCC is co-located with tram maintenance or it is provided at a separate location.

8.2. This guidance should read in conjunction with LRG 29.0 Guidance on Human Factors in Operations Control Centres.

8.3. The location and facilities of the OCC would include the following:

- Be specifically zoned within the depot site and building(s) as separate functionality with secure and authorised access; and
- Comprise of an OCR and CER, both having sufficient capacity, layout and facilities such that project operations staff can efficiently, effectively and safely deliver the project operations in accordance with the network's performance measures.

Operations Control Room (OCR)

Functionality

8.4. The functions of the OCR typically include the following:

- Is the place from where all supervisory, control and communication activities emanate and through which all operational voice communication is routed; and
- Provide for the safe and efficient management of:
  - Tram movements around the network;
  - The network's electric traction and ancillary power supplies; and
  - All remote electrical, electronic and telecommunications equipment required for project operations.

OCR Layout

8.5. The OCR should typically have a clear view of the depot external stabling area and tram entry / exit point, and with the associated CER set immediately below or immediately adjacent with the following must be enabled:

- Interaction of OCR staff to work and interact with each other efficiently and effectively;
- Access to / from the main administration and support offices located at the depot;
- Clear visibility over the entrance and exit to at least one of the workshop tracks, the stabling tracks and as much of the running line as practicable; and
- Comprise of a number of workstations, at which OCR staff sit and use such equipment to safely remotely control or retrieve data from the supervisory and control system.

8.6. Access to the OCR should be sited to minimise disturbance to OCR staff, their interaction and communication and sight of the Tram Location and Detection System (TLDS) overview display.

8.7. The OCR would typically have an adjacent lobby area and preferably a viewing area from an adjacent corridor.

8.8. The design and implementation of the OCR typically needs to provide sufficient and effective area for the following operations personnel functions / roles:

- Operations Duty Manager(s) who is responsible for overall control of the network, minute-by-minute delivery of the services, the safety of the project operations; and required to be present to book tram crew on and off duty.
- Operations Shift Controller(s) who is responsible for the minute-by-minute operation of the network and the services ensuring service perturbations risks are minimised and tram crew are aware of the current state of the network and the Services.
- Operations Information and Security Supervisor(s) provide support to the Duty Manager and shift Operator by monitoring the positions of trams, monitoring and editing of passenger information displays, monitoring of CCTV and passenger help / emergency help points. This post will also take the primary role in ensuring passenger information and security.
- Operational support staff provide support to the information and security supervisor under certain perturbed situations.

Operator Interface

8.9. Detailed guidance relating to the system and subsystem interfaces with OCR Staff are described in LRG 31.0 Network Supervision and Management Guidance. However, the following key considerations and requirements are listed below in relation to design and implementing the spatial and buildings design of the OCR along with the illustration provided in Figure 8.1.

Figure 8.1: Example Spacing in an Operations Control Room

8.10. The OCR and operator interface(s) should be such that there is minimal disturbance, stress and duress placed upon the OCR staff in exercising their duties during either under normal or degraded conditions of service and / or the network.

8.11. A diagrammatic overview representation (TLDS overview display) of the current status of the services and status of the network should be provided in the OCR. Such display must be clearly visible to all OCR staff. It may take the form of a plasma / OLED type display but must always, in real time, display the current TLDS information in the same format as presented at the operators' workstation(s).

8.12. Requirements for operator workstations include the following:

- Be located within line of sight of each other to allow visual signals to be given between OCR staff; and
- Have a clear and unobstructed view of the TLDS overview display.

8.13. The OCR should be furnished with modern ergonomic furniture to assist the OCR staff and reduce fatigue. For further guidance in relation to fatigue, refer to LRG 6.0 Fatigue Management Guidance.

Building Requirements

8.14. As the OCR is critical to the effective and safe execution of project operations, there are specific requirements which need to be incorporated into its design and implementation.

8.15. These would typically include protection from the consequences of electrical supply failure. Any loss of power or changeover to battery supplies should not cause a loss of integrity in the ability to safely control and manage the project operations, and is so doing provide the following:

- A working environment that minimises distraction and fatigue, to avoid the risk of error by the staff responsible for the control of operations;
- Equipment essential for the safe management and control of project operations;
- Adequate facilities for the OCR staff to make / obtain refreshments, store food for their turn off duty;
- Effective management and maintenance of cabling, and equipment and maintenance power supply distribution. Cables should be continuously screened through the aperture in the floor. Local cabling between the OCR and the CER ducts should be installed beneath a raised floor within the OCR; and
- Should be environmentally controlled to minimise the effects of room heating due to equipment heat dissipation. Any heating / cooling vents should not be positioned over the work area of the OCR staff and should be placed in position to minimise localised chilling effects. Local control of the heating should be achieved with a wall mounted manual control in the OCR.

8.16. Ambient LED lighting should be provided and controllable from an area near the exit and entry points to the OCR.

8.17. Each OCR staff workstation should be able to control the local lighting, so that screen light reflections should be reduced.

Central Equipment Room (CER)

8.18. The primary purpose of the CER is to house the supervision and control system's centralised equipment that supports the OCR's objective to manage the project operations, and deliver the services effectively and safely.

8.19. In order to minimise cable management, differing power distribution needs and downtime in any supervisory and control system fault finding, the CER should be situated either directly adjacent to, or directly below the OCR.

8.20. The CER will typically house centralised ('head-end') equipment of the following systems:

- Cable termination and management systems fire alarm system;
- Central data recording and storage;
- CCTV and video surveillance system;
- Local area network server;
- Local printers;
- Local terminals (maintainers workstations);
- Master time server;
- Operation radio / communication system (including base-station if required);
- Operational data network control centre node;
- Passenger help / emergency help point;
- Passenger information display subsystem;
- Performance monitoring and management system;
- Point control and indication system;
- Point heating control system;
- Public address system;
- Remote equipment supervision system;
- Security and access system;
- Telephone network private automatic branch exchange (or equivalent);
- Traction power supervision system;
- Tram location and detection subsystem; and
- Voice recording and playback.

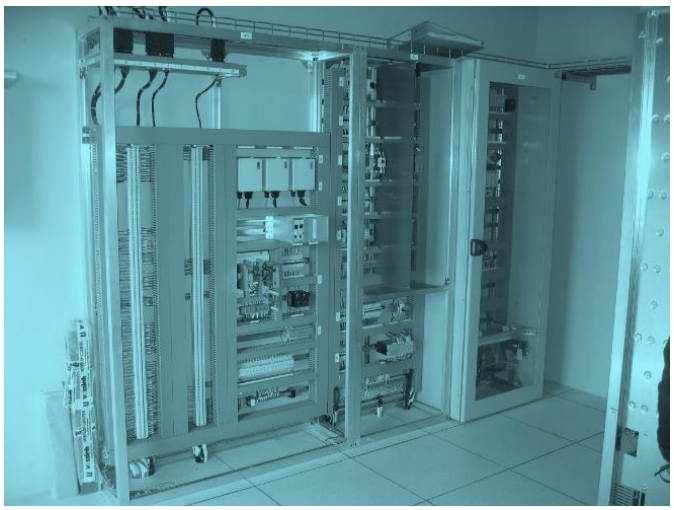
CER Building Requirements

8.21. Subsystem equipment in the CER is typically electrical or electronic in nature. As such it would primarily be contained in freestanding cubicles, laid out to afford easy accessibility (as illustrated in Figure 8.2) with the following features:

- Cubicle doors, when opened should not impinge on access to equipment;
- Equipment cubicles and the equipment within them should be placed such that the length of cabling runs are minimised; and
- The CER floor should be sealed to minimise dust ingress into the equipment cubicles and ensure that no static build-up occurs.

8.22. Entry to the CER must be on a controlled access basis. Therefore, an appropriate door access system is required.

Figure 8.2: Example Storage of Subsystem Equipment in the CER



8.23. To facilitate ease of cable management and avoid human tripping and contact hazards, CER cabling design and implementation should provide the following cabling:

- From the equipment to sub-systems located outside the depot exit their respective equipment cubicle(s) through their cubicle bases into cable runs contained in the CER floor and routed through an exterior aperture in an external wall of the CER;
- From the equipment to sub-systems located at the Operator Human Computer Interface (HCI) in the OCR exit their equipment cubicle(s) through the cubicle bases into cable runs contained in the CER floor and are then routed through an aperture in the CER ceiling into the OCR; and
- Are clearly identified by permanent labeling in an approved format.

8.24. All subsystem equipment must be supported by the provision of a dual uninterruptible power supply / diverse electrical supplies that provide power for a duration of not less than four hours from the time when the primary power source was lost.

8.25. Risk and performance analysis should be undertaken to identify the appropriateness of providing a back-up generator or energy storage. If such need is demonstrated to delivering the services in accordance with the performance measures in power outage circumstances, then such generation / energy storage should be designed and implemented by using the most sustainable economic means.

8.26. The equipment located in the CER should have the option to run either from a 230 / 240VAC 50Hz or 415VAC 50Hz supply.

8.27. Appropriate switched mains sockets should be located on the walls and in the floor area close to the equipment locations.

8.28. A suitably located wall-mounted supply distribution should be provided to safely and easily enable disconnection of supplies in the event of an emergency.

8.29. Smoke, temperature alarms and an automatic and manually operated fire extinguishing system should be provided. The fire operating system should not damage the equipment when activated nor be injurious to project operations staff in the CER when such system(s) is activated.

8.30. The CER needs to be environmentally controlled to minimise the effects of room heating due to equipment heat dissipation. Vents should not be positioned over the work areas of project operations staff, nor directly above equipment cubicles, whilst positioned to minimise localised chilling effects and prevent dust ingress.

8.31. LED and ambient LED lighting should be provided and positioned to illuminate the front and rear of the equipment cubicles, but should not be located directly above equipment cubicles.

8.32. In the event of power failure, emergency lighting should operate for a minimum of four hours and maintain the level of illumination in the room.

Maintainers' Workstations

8.33. To safely deliver services in accordance with the performance measures and network's SMS, the CER should provide space and equipment for maintainers to monitor, maintain, interrogate and undertake such other tasks on the systems, subsystems and equipment located within it. The following would be expected within the CER:

- Space for two workstations provided which comprise a local display, HCI and keyboard to enable the interrogation of the server or other related equipment for diagnostic or maintenance purposes; and
- Workstations would be:
  - Of similar design to their equivalents in the OCR with a greater level of more detailed access for their users with governance managed by password and user groups' membership; and
  - Situated with a full view of the equipment in the CER.

9. Administration, Management and Welfare

9.1. To provide effective communications between functions / disciplines to safely deliver the services in normal and or degraded periods, the staff responsible for administration and management of the network are usually located in the same or adjacent building(s) as those responsible for tram / vehicle maintenance and OCR staff. This same accommodation would also provide for tram crew, cleaning and infrastructure maintenance staff requirements, for example lockers, workspace and welfare facilities for project operations staff located at the depot.

9.2. As such design and implementation of any depot needs to have sufficient capacity to accommodate the required maximum number of project operations staff necessary to support delivery of the normal services at any given time on each and every day the services are provided. This should include the following:

- Adequate locker and changing space, drying facilities, toilets and showers;
- A mess facility including a limited self-service kitchen facility;
- Necessary domestic plant rooms; and
- First aid room suitable for all staff and accessible from the first floor and with an external vehicle access.

9.3. Project operations staff access should be arranged as the following:

- Adjacent to the locker rooms (as far as practicable);
- Convenient for external access; and
- Appropriate security.

9.4. The different spaces / zones used by the different functions / organisations need to be arranged, segregated or grouped logically together with the appropriate means of access they require.

9.5. Natural light in offices should be maximised and all rooms should be located within the building in accordance to their function. This should be supplemented by artificial lighting (for example, LED) consistent with the tasks undertaken and the hours of operation of the facility.

9.6. Office lighting should be to CIBSE guidance[4] that encourages the maximum use of daylight in offices. Use of lighting controls (i.e. daylight sensing, presence detection) should also be provided which also saves energy by utilising daylight wherever and whenever possible.

Tram Maintainer Management Facilities

9.7. Further to the guidance on tram maintenance and servicing facilities in Section 7, in relation to trams, there are support and management facilities required for this function which include the following functions / roles:

- A small store for workshop cleaning equipment;
- Tram maintenance management office; and
- Tram maintenance general office.

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Infrastructure Maintainer Specific Facilities

9.8. To support delivery of the service, the network's asset will need to be appropriately maintained, requiring planning and management. Usually this would be centralised at the main depot.

9.9. Accommodation and support facilities for infrastructure maintenance function should, in addition to that described in Section 7, provide for the following functions / roles:

- Infrastructure maintenance management function; and
- Infrastructure maintenance general office.

Administration and Management Facilities

9.10. In addition to the OCC requirements detailed in Section 8, the accommodation set out below is required as a minimum to support project operations, and must be related in all respects to the numbers of staff to be employed and based at the depot:

- A lobby outside the OCR, with sufficient space for the incorporation of the necessary furniture and technical equipment used to store and manage the handheld radios and ticketing equipment and their batteries, together with one desk space;
- A reception area including an allowance for a reception desk and chair(s);
- Office space for the following roles / functions:
  - General management;
  - Operations management;
  - Safety and performance management;
  - Engineering office;
  - Duty Manager and supervisors;
  - Finance and commercial management; and
  - General office.
- Cleaning office and store;
- Interview room (close to the operations management location);
- Meeting room (close to the reception);
- To maximise efficiency it is recommended that two training rooms, one larger (for example, a capacity of 30) and one smaller (for example, a capacity of 15). The larger should be able to be subdivided, broadly in half;
- A store for uniforms and other small operational equipment;
- A location for photocopying;

10. Energy

10.1. The design and implementation of energy supplies and distribution systems for the depot(s) must have sufficient capacity that enables the services to be delivered in accordance with the system's performance measures and project operations including when under normal and degraded operations. As such, the overall energy systems should include but not be limited to the following:

- Main (11kV) power transformer and low voltage switchboard;
- Sub-mains distribution and main equipment;
- LV power distribution;
- Power supply to mechanical plant and controls;
- Back-up supplies (redundancy in system architecture, energy store or fixed standby generator);
- Uninterruptible power supplies;
- Data distribution and information technology (IT) systems supplies (including operations IT systems);
- Fire protection system supplies;
- Power supplies to CCTV, security and access control systems supplies;
- Power supplies to lighting both internal and external, plus emergency lighting supplies;
- Cable containment;
- Lightning protection and depot equipment earthing; and
- Commissioning of systems and training.

10.2. The depot energy system must be commensurate and compatible with the energy system deployed on other parts of the network.

10.3. For additional guidance relating to OLE, refer to LRG 21 OLE Maintenance and Reference Manual.

Depot Substation

10.4. Typically, with current-state-of-the-art tramway energy systems, depot(s) are provided with their own substations which take incoming supply from the Distribution Network Operator's (DNO) distribution network and transform said supply into the energy capacities and types required to deliver the energy requirements for the depot(s)'s functions. See Figure 10.1 for an illustration of such a substation.

10.5. Sometimes, depot substations are also required to distribute energy to other parts of the network and therefore are sized and connected to the network's distribution architecture accordingly. The following sets out the guidance for this scenario.

10.6. Energy to the depot should be provided and distributed from a purpose-built substation located within the depot confines as illustrated in Figure 10.1.

10.7. Where practicable, it is advantageous that incoming supply to the depot substation be provided from a sustainable and dependable means of electricity generation; i.e., maximise

the opportunity to have power provided from DNOs who only offer energy from renewable sources.

Figure 10.1 Typical Depot Substation

10.8. A depot substation must have capacity to undertake the following roles:

- Be capable of supplying 100% rated load continuously, and as far as practicable: at 150% rated load for 2 hours following temperature stabilisation at 100% rated load or at 300% of rated load for one minute following temperature stabilisation at 100% rated load;
- Accommodate and be commensurate and compatible with the energy subsystem deployed on the running line. This should be defined by the outputs from the network's operations planning and modelling workstream;
- Accommodate separate 11kV / 400V LV transformer and distribution switchgear should be accommodated fed from the main 11kV supply located in the depot substation; and
- Provide a depot low voltage switchboard capable of being energised from an external / mobile generator via socket and plug with an interlocked isolator. This should provide 400VAC supplies to essential services within the depot complex.

Depot Traction Power Systems

10.9. The alignment of depot traction power systems must be commensurate and compatible with the trackwork internal and external to the depot building(s) such that trams can move in to, out of and around the depot under their own power.

10.10. Depot trackwork, including that inside the vehicle maintenance workshop, should be electrically insulated from the running line, and tied to a common earthing system for the whole depot site.

10.11. Suitably located insulating block joints should be provided to support the depot operations taking cognisance of track layout and OLE requirements.

10.12. The depot traction supply must be able to be drawn from the running line of the network during instances when the depot traction substation is not available. This reconfiguration should be able to be implemented via the supervisory and control system.

10.13. A foreseeable single failure in the high voltage supply to the depot substation must not result in an interruption to either the depot traction or to any of the depot ancillary supply of more than 5 minutes with no requirement for manual switching;

Overhead Line Electrification (OLE)

10.14. The depot traction power system must provide OLE configured to support the depot operations and functions necessary to deliver project operations in accordance with the system's performance measures. As such, OLE will need be to be provided to the following:

- All external tracks; and
- Tracks inside the vehicle maintenance workshop, sand plant and wash plant.

OLE Outside the Main Workshop

10.15. A fixed termination single contact wire system (supported or unsupported) would usually be provided and configured to accommodate the wire height constraints at the depot.

10.16. All isolators should be manually operated with two positions, 'closed to feeder' and 'closed to earth'.

10.17. OLE sectioning should allow maintenance tasks without disruption to other operations, for example, the wash plant.

OLE in Main Workshop

10.18. Each maintenance berth must be capable of being electrically isolated separately.

10.19. Live line status indication must be provided to / for the following:

- Tram drivers: standard tramway signals outside doors to each wired part of vehicle workshop, showing STOP when line dead and PROCEED when line live;
- Project operations staff in the workshop: red (live or dead but not earthed) / green (earthed) indicators at each berth; and
- Should be visible from as much of the workshop as possible, from the rolling stock office and (preferably) from the window from the OCR into the vehicle workshop.

10.20. Vehicle workshop OLE wire height should be high due to safety and also as it facilitates pantograph set-up.

Safety Interlocking System

10.21. A safety interlocking system must be provided that is essentially mechanical key system that prevents the following:

- Access to a tram roof when the OLE above it is not earthed, either by preventing access to the gantry or by preventing access from gantry to tram;
- Use of overhead crane where there is a conflict with live OLE; and
- Use of overhead crane where it would run into a tram on jacks.

10.22. If there is tram roof equipment near the end of a maintenance gantry such that a person working on it is at risk of falling off the end, end gates to high level gantries should be provided with interlocking such that OLE cannot be live whilst a gate is across.

Ancillary Power Systems

10.23. The depot needs to be provided with appropriate electricity supplies including 400V for individual items of workshop equipment both inside and outside the depot building, 230V for internal domestic use and 110V for small tools.

10.24. Auxiliary supplies would usually be provided from the depot traction substation with a suitably sized uninterruptible power supply.

11. Supporting Plant and Equipment

11.1. In order for the services and project operations to be delivered in accordance with the performance measures, and in order to respond to emergency and out of course events, the network will require several ancillary services and equipment. Such equipment would typically be stored and maintained at the main depot, and would include the following.

Re-railing Equipment

11.2. An appropriate package of re-railing equipment needs to be provided so that derailed trams on the depot or running line of the network can be safely and efficiently re-railed as illustrated in Figure 11.1.

Figure 11.1: Typical Re-railing Equipment

11.3. The following are key considerations in providing such re-railing equipment:

- Compatibility with the vehicle type / make and any and all special characteristics of the network's alignment; and
- Ability to be packed together, either as a module to fit the road-rail vehicle, or to fit in a separate road vehicle to enable easy transportation to the derailment location.

Road-rail Vehicles

11.4. A road-rail vehicle appropriate to the network's alignment and nature of project operations tasks to be undertaken will need to be provided; see a typical vehicle in Figure 11.2. Basic requirements will need to be agreed, but would typically include a Hiab-type crane of a capacity, and exchangeable body pallets.

Figure 11.2 Typical Road-rail Vehicle

11.5. Particular attention needs to be applied to the suitability of the vehicle and its equipment for working on or near the network's OLE. This would include any large working platform which does not need outriggers down, so it can be moved quickly between structures, and moved along the track and highway slowly when there are people on the platform inspecting the OLE.

11.6. The vehicle will need to have mechanism(s) which allow easy and safe attachment and detachment of exchangeable fittings appropriate to the various tasks of the project operations. These would include the following:

- Rotary, or other type of, sweeping brush for cleaning the tramway path, tramstop platforms etc.;
- Attachable water tanks and jet-wash equipment for general cleaning, but also for removing debris and detritus from grooved rails and pointwork;
- Where the network deploys grass-track, a suitable cutting and mowing attachment; and
- Module suitable for general cleaning of grooved rail.

Depot Shunter

11.7. Trams will need to be moved around the depot. Sometimes these vehicles will not be able to move under their own power so, a shunting device will need to be provided as is illustrated in Figure 11.3.

11.8. A battery shunter, or similar should be provided to move trams over the wheel lathe if safety verification cannot be achieved for trams to move over the wheel lathe under their own power.

11.9. Such shunting device should have the following attributes:

- Simple to operate either by hand via a hand-held controller or by riding on-board with appropriate controls / instruments;
- Fitted with visual and audible device to alert project operations staff of its movement; and
- Be compatible with the track gauge of the network and the trackwork of the depot.

Figure 11.3: Typical Shunting Device

Road Vehicles

11.10. There will be a requirement for a number of road vehicles to support the project operations. The volume and type of such vehicle fleet is dependent upon the size and complexity of the network and the nature of tasks to be undertaken. Typical vehicles to be considered include the following:

- Pick-up truck / lorry for materials / equipment transportation;
- Small van; and
- Minibus or similar if there is need to transport project operations staff between locations (for example, tram crews).

11.11. In all cases, when identifying the need for and procuring such road vehicles, due cognisance should be taken of their powertrain. Wherever practicable electric and / or hybrid vehicles should be deployed with the associated charging facilities provided.

12. Changes to Depots if Using New Technologies

12.1. There are several existing and / or emerging technologies which could be utilised on tramways. They are also applicable to potential branch line railway conversions / modifications. This section looks at the key implications for depot design and implementation when considering deploying some of these technologies.

Self-powered Trams

12.2. There are emerging technologies that are being incorporated into vehicle design resulting in vehicles available with hydrogen and battery / energy store powertrains, coupled with wireless charging. Both have the potential to deliver significant economic, environmental and supply chain benefits and reduce risks to safety from exposure to and electrocution from high-voltage electricity, and working on or near OLE.

Hydrogen Trams

12.3. The key changes to depot design and implementation brought about by adopting this technology will include the following (not exclusively):

- There is no requirement for the typical electrification and power traction power and OLE system within the depot, thus there is the potential for significant cost and construction duration savings as well as to the running line of the network;
- The depot would still need a substation or equivalent, in order to provide non-traction power electrical supplies; and
- Provision would have to be made for storage of and refuelling trams using a highly flammable product in accordance with the associated Regulations and planning. This will impact upon:
  - Location of fuelling facilities taking cognisance of hydrogen storage neighbouring land and properties and fuel delivery;
  - Changes to the network's SMS with respect to changes in methods and approaches for safe project operations; and
  - Changes in the depot throughput assumptions and processes.

Battery Trams and Wireless Charging

12.4. This technology brings about the fundamental change of localised charging of trams through wireless charging pads located at tramstops derived from revised operational modelling and planning, and at the depot.

12.5. The key changes to depot design and implementation brought about by adopting this technology will include the following (not exclusively):.

- There is no requirement for the typical electrification and power traction power and OLE system within the depot, therefore significant cost and construction duration savings are possible. This would also apply to the running line of the network;
- Each tram berth within the stabling facility would need to be fitted with wireless charging pads;
- Each tram would need to be fitted with an appropriate vehicle interface unit (pick-up device, regulator);

- A substation, or equivalent, would still be needed to supply ancillary power to the depot and electricity to the system's inverters and equipment; and
- Changes to the network's SMS with respect to changes in methods and approaches for safe project operations.

12.6. There should not be any major implications of this technology on throughput assumptions and processes.

Solar Energy Harvesting, Storage and Distribution

12.7. As solar power and solar thermal energy is being explored and implemented, this can be deployed in small and more local energy distribution networks including for tramway networks as the primary means of traction and ancillary power. This has the potential to move energy provision to one where any grid-based connection is solely used as a back-up supply in case of low levels or stored energy.

12.8. Key changes and considerations in adopting this approach would include the following (not exclusively):

- Maximising building roof space, parking area space (including canopy provision) to install solar panels and / or solar thermal panels to harvest electricity for depot power, heat for heating and hot water systems. Similar approach using tramstop parking and structures could permit the potential for a renewable energy distribution network for whole network; and
- A typical substation is not necessarily required as this may be replaced by an energy store and appropriate electrical apparatus to transform and distribute the energy at the required voltage(s).

12.9. This technology could be easily used in tandem with a battery powered tram and wireless charging technology.