MOTT MACDONALD

# Use of GB Mainland Overhead Line Equipment (OLE) support structures

To house small cells and wireless antenna

21 February 2020

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**Document reference:**

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# Contents

# Foreword

Today over a third of Great Britain's railways are electrified using Overhead Line Equipment. As the Chief Mechanical and Electrical Engineer at Network Rail it is my role to ensure that we continue to safely deliver and maintain this asset for the benefit of our train operators and passengers.

Looking ahead, and aware of how OLE structures are increasingly being used in other countries to address rail corridor mobile connectivity challenges, my team and I were pleased to support the Department for Transport in the development of this report.

There is potentially a sizeable opportunity to reduce the costs and time to deploy trackside telecoms infrastructure, particularly to support 5G, through re-using these structures.

Of course, Network Rail is not able to state categorically that every structure can be used without detailed assessment. However, this report addresses the key considerations – be these mechanical, electrical or safety – and provides guidance on our product approvals and common safety method assessment processes.

I hope you will find this report beneficial.

Philip Doughty

Network Rail

July 2020

# Executive Summary

In 2017 the National Infrastructure Commission (Connected Future) set out their recommendation that “Rail passengers should have high capacity wireless connectivity … achieved through a delivery model that utilises trackside infrastructure to provide an open and accessible mobile telecommunication and backhaul network…”

As Overhead Line Equipment (OLE) structures are available across about a third of the 11,000 miles of the railway network, there is significant potential to utilise these existing structures to mount equipment and reduce the need for additional masts to achieve this outcome.

Mott MacDonald was commissioned by the Department for Transport (DfT) to explore the feasibility of utilising OLE structures to mount small cells and/or wireless antennas. The feasibility study focused on the physical location and mounting of equipment, and the subsequent impact on design, installation and maintenance. Particular considerations identified during design included the need for assessment of structural condition and the effect of weight, wind loading and deflection, as well as identification of potential safe areas of locating equipment which achieves the required mechanical and electrical clearances.

Following industry-wide stakeholder consultation and engagement, it was established that it is feasible to utilise the majority of OLE structures to mount small cells and/or wireless antennas, subject to compliance with applicable legislation and standards.

Key requirements have been identified associated with the safe location, design, installation and maintenance of any equipment to be mounted on OLE structures. The rationale for each set of requirements is provided, followed by relevant guidance.

A number of considerations have been identified that are dependent upon the chosen antenna/technological solution. Whilst general requirements and guidance is provided in these areas, further consideration will be required in due course as potential solutions and applications are developed.

As well as understanding the requirements to be met to facilitate the safe design, installation and maintenance of potential OLE structure-mounted equipment, there is also a need for interested parties to understand the availability of OLE on a given route, including the type of OLE system and the quantum and range of OLE structure types present. This information is held by the asset owner, Network Rail, and will be needed to inform any decision on whether to use existing OLE structures or pursue an alternative approach.

# Acronyms and Abbreviations

| | |
|---|---|
| Alternating Current (AC) | Electrical current that changes direction 50 times per second. |
| Autotransformer Feeder System (ATF) | System to be used for supplying power to the OLE. Incorporates ATF cables, generally one per track, attached to OLE masts and connected to autotransformer stations at intervals alongside the track. |
| Basic insulation | Insulation of hazardous-live-parts, which provides basic protection. Note: this concept does not apply to insulation used exclusively for functional purposes. [IEV ref 195-06-06] |
| Basic protection | Protection against electric shock under fault-free conditions. [IEV ref 195-06-01] |
| Cantilever | OLE structure comprising horizontal or near horizontal members supporting the catenary projecting from a single mast on one side of the track. |
| Catenary | The longitudinal wire that supports the contact wire. |
| Conductor | Any insulated wire, cable or bar that carries electric current. |
| Contact wire | Carries the electricity which is supplied to the train by its pantograph. |
| Contact & catenary wire tensioning | In order to keep the wires taut, they are in lengths of no more than 1500m, and tensioned at each end. |
| Direct Current (DC) | Electrical current that flows in one direction, like that from a battery. |
| Dropper | Wires suspended vertically from the catenary at regular intervals to support the contact wire. |
| Feeder station | A facility next to National Grid electricity transmission lines that extracts 25,000V and transmits it to the railway. The spacing of these stations depends on the electrification system used. |
| Functional insulation | Insulation between conductive parts, necessary for the proper functioning of the equipment. [IEV ref 195-02-41] |
| Gauge | Set of rules including a reference contour and its associated calculation rules allowing defining the outer dimensions of the rail vehicle and the space to be cleared by the infrastructure. |

| | |
|---|---|
| | Note: According to the calculation method implemented, the gauge is static, kinematic or dynamic. |
| Insulators | Components that separate electrically live parts of the OLE from other structural elements and the earth. Traditionally ceramic, today they are often synthetic materials. |
| Kinematic envelope | The space that defines the train and all its allowable movements - rocking, swaying, bouncing, for example. |
| Live part | Any conductor and any conductive part of electrical equipment intended to be energised in normal use. [IEV ref 195-02-19-modified]. Insulators are considered to be live parts. |
| Loading gauge (vehicle gauge) | The dimensions – height and width – to which trains must conform in order to avoid colliding with line-side structures such as bridges and platforms. |
| Mast | Trackside column, normally steel, that supports the OLE. |
| Mid-point anchor | At the midpoint of the standard length of OLE wires, the wires are fixed in position to keep the contact wire stable. |
| Neutral section | A length of electrically isolated or non-conducting material incorporated into the contact wire to completely separate electrical sections of OLE. It may take the form of a short insertion in the contact wire or that of an extended overlap. |
| Overhead contact line (OCL) | Contact line placed above (or beside) the upper limit of the rail vehicle gauge and supplying vehicles with electric energy through roof-mounted current collection equipment. [IEV ref 811-33-02]<br>Note: where this includes, in addition to all current-collecting conductors, the following elements: reinforcing feeders; cross-track feeders; disconnectors; section insulators; overvoltage protection devices; supports that are not insulated from the conductors; insulators connected to live parts; along-track feeders; conductors connected permanently to the contact line for supply of other electrical equipment; earth wires and return conductors. |
| Overhead line electrification equipment (OLE) | Overhead line electrification equipment, which supplies electric power to the trains. |
| Overlap | Each length of the contact wire overlaps with the next so that the pantograph slides smoothly from one to the other. |

| | |
|---|---|
| Pantograph | The device on top of the train that collects electric current from the contact wire to power the train. |
| Passing electrical clearance | The distance, being created by a momentary reduction of the static electrical clearance, caused by the dynamic interaction of the pantograph and the OCL during the passage of electric trains, or a train in motion at a specific location. |
| Reinforced insulation | Insulation of hazardous-live-parts, which provides a degree of protection against electric shock equivalent to double insulation.<br>Note – Reinforced insulation may comprise several layers which cannot be tested singly as basic insulation or supplementary insulation. [IEV ref 195-06-09] |
| Return circuit | All conductors which form the intended path for the traction return current and the current under fault conditions. [EN 50122-1:2011+A1:2011] |
| Return conductor | Conductor paralleling the track return system and connected to the running rails at periodic intervals. [EN 50122-1:2011+A1:2011] |
| Static electrical clearance | The distance forming insulation in air between:<br>a) Exposed live parts of the OCL system and the parts of rail vehicles that are earthed via the fixed installation.<br>b) Exposed live parts of the OCL system and fixed assets under the control of different infrastructure managers.<br>c) Exposed live parts of electric rail vehicles and earthed parts of the OCL system.<br>d) Exposed live parts of electric rail vehicles and fixed assets. |
| Structure gauge | The defined space into which a structure must not intrude, to avoid trains colliding with it. This is larger than the kinematic envelope and loading gauge. |
| Standing Surface | Any point on a surface where persons may stand or walk about without great effort |

# 1 Purpose and Introduction

## 1.1 Background

In 2017 the National Infrastructure Commission (Connected Future) set out their recommendation that “Rail passengers should have high capacity wireless connectivity … achieved through a delivery model that utilises trackside infrastructure to provide an open and accessible mobile telecommunication and backhaul network…”

To achieve ultra-high track to train data speeds of 1Gbps-plus, thousands of small cells may be required, potentially spaced every 300 to 500m (circa) along rail lines. At present, existing GSM-R masts are typically spaced every 3 to 5km (circa). Deploying thousands of 5 to 8m tall masts to mount these small cells to provide line of sight communications to train roof tops would be potentially very expensive and time consuming (including the time associated with obtaining planning permission, possessions and subsequent mast builds).

Today, Overhead Line Equipment (OLE) is available across about a third of the 11,000 miles of the railway network, and hence there is significant potential to utilise these existing structures to mount equipment and reduce the need for additional masts across large parts of the rail network, and also potentially reduce the visual impact.

## 1.2 Purpose

Mott MacDonald was commissioned by the Department for Transport (DfT) to explore the feasibility of utilising OLE structures to mount small cells and/or wireless antennas. The feasibility study focused on the physical location and mounting of equipment, and the subsequent impact on design, installation and maintenance.

Key requirements have been identified associated with the safe location, design, installation and maintenance of any equipment to be mounted on OLE structures. The rationale for each set of requirements is provided, followed by relevant guidance.

## 1.3 Stakeholder Consultation

The following stakeholders were involved and actively participated in two workshops that were held to discuss the requirements of this guidance note:

- Network Rail
  - Network Rail Professional Head of OLE
  - Network Rail Telecoms (NRT)
- Rail Delivery Group (RDG)
- Office of Rail and Road (ORR)
- Department for Transport (DfT)
- Railway Safety and Standards Board (RSSB)
- Mobile Network Operators (MNO’s)
- Equipment Manufacturers
- Telecommunication Consultants
- Telecommunication Contractors
- Other interested parties

## 1.4 Structure of this Document

This document sets out a series of requirements and the rationale for those requirements, in some cases followed by relevant guidance associated with the feasibility of fitting small cell / wireless connectivity equipment to OLE support structures found across the rail network of Great Britain.

To guide the reader, the salient considerations associated with fitting small cell / wireless connectivity equipment to OLE support structures are discussed in the following parts:

- Part A - **Physical Mounting** considerations.
- Part B - **Design Assurance** considerations.
- Part C - **Installation** considerations.
- Part D - **Electrical** considerations.
- Part E - **Maintenance** considerations.
- Part F - **Product Approvals**
- Part G - **Spectrum & Connectivity-**related considerations.
- Part H - **Areas Outside Scope** which require further consideration

## 1.5 Limitations of Scope

A number of considerations have been identified that are dependent upon the chosen technological solution and application and sit outside the scope of this commission, namely:

- Spectrum.
- Equipment design (Concept, Reference, Detailed).
- Electrical considerations – impact on cable routes and quantum/type/routing of cables, provision of power supplies, earthing and bonding and effect of EMC.
- Provision of lineside connectivity including backhaul.
- Associated safety case/product approvals.
- Planning and Consents.
- OHLE structures/solutions within tunnels.
- Applicability to HS1 and HS2.

A number of considerations have been identified that are dependent upon the chosen antenna/technological solution. Whilst general requirements and guidance is provided in these areas, further consideration will be required in due course as potential solutions and applications are developed.

As well as understanding the requirements to be met to facilitate the safe design, installation and maintenance of potential OLE structure-mounted equipment, there is also a need for interested parties to understand the availability of OLE on a given route, including the type of OLE system and the quantum and range of OLE structure types present. This information is held by the asset owner, Network Rail, and will be needed to inform any decision on whether to use existing OLE structures or pursue an alternative approach.

## 1.6 Application of this Document

The guidance presented within this document aims to enable interested parties to understand the requirements that will need to be considered to safely design, install, operate and maintain small cell / wireless antenna (and associated equipment) on Network Rail OLE structures. The document does not specify or constitute a recommended method of complying with these requirements.

## 1.7 Health and safety responsibilities

Users of documents published by DfT are reminded of the need to consider their own responsibilities to ensure health and safety at work and their own duties under health and safety legislation. DfT does not warrant that compliance with all or any documents published by DfT is sufficient in itself to ensure safe systems of work or operation or to satisfy such responsibilities or duties.

## 1.8 Approval and Authorisation

The content of this document was approved and authorised by DfT November 2019.

# 2 OLE within the UK Rail Network

The 25kV Overhead Line Electrification System design has evolved over the years as elements of the system have been refined and improved to meet changing demands of linespeed, conductor size, constructability, reliability and maintenance considerations. This has left a legacy of differing designs, masts and structures across the UK, see below for information and routes in use today.

**Table 1: Development of the OLE Systems from 1954 to present day**

| System | Description |
|---|---|
| **Great Eastern (GE) & Manchester - Sheffield - Wath (MSW)** | 1500 V DC Overhead Line. Developed by London and North Eastern Railways (LNER) and British Rail (BR). First installed in 1949 on lines out of Liverpool Street station. Then installed on Manchester – Wath – Sheffield route in 1954.<br>Has been subsequently upgraded to 6.5kV and then 25kV over the years. |
| **Shenfield - Chelmsford - Southend (SCS)** | 1500 V DC Overhead Line. The Shenfield – Chelmsford – Southend (SCS) range was installed in 1956 as extension to lines using GE Range, replaced GE Range. Has been subsequently upgraded to 6.5kV and then 25kV over the years. |
| **Mark 1** | Developed by British Rail and Balfour Beatty in the 1960's. Used on first phase of the WCML. |
| **Brown Boveri Range** | Initially developed by Pirelli for the Glasgow South Suburban electrification as an alternative to MK1 but only implemented on the Neilston Branch as work was taken over by BICC and Mk2 system was implemented. |
| **Mark 2** | The Mk2 range had a short life and confined to installation on Glasgow suburban lines during the 1960's. Pioneered the use of galvanised supports and registration equipment. |
| **OLE Master Index (OLEMI) -**<br>**Mark 3a**<br>**Mark 3b**<br>**Mark 3c**<br>**Mark 3d**<br>**Mark 4**<br>**Mark 5**<br>**UK1** | Developed in the 1970's due to demands for cheaper OLE build requirements. Developed by British Rail and now owned by Network Rail (over 1.300 drawings). Developed as a modular system where one component could be used for multiple functions. This range contains the Mk3,3a,3b,3c,4,5 and UK1 ranges.<br>Refinements within the Mk3 range were associated with rectifying failure modes experienced in-service.<br>Mk4 was designed for use with the Advanced Passenger Train (APT) but was never implemented due to failure of the APT project.<br>Mk5 was a heavy current version of Mk3c and only used at Dollands Yard.<br>UK1 was developed in the late 1990's as part of the WCML modernisation and to raise WCML line speeds. This covered the upgrades of Mk1 and Mk3a equipment ranges to speeds of 200km/h and 225 km/h. |
| **ATF** | Developed around 2000 for upgrade to WCML to allow Auto Transformer feeding. |
| **SICAT Range (Siemens Catenary)** | Developed in 2005 for the Larkhall to Milngavie project and subsequently used on the Shields to Gourock project. |
| **GEFF (Great Eastern Furrer Frey)** | Developed by Furrer Frey and Network Rail for Great Eastern route upgrade. |
| **Series 1** | The Series 1 range was introduced by Network Rail as part of the National Electrification Programme as a 2x25kV autotransformer configuration, providing TSI-compliant multiple pantograph 225km/h-rated sagged simple OLE system which addressed the addressed the problems, limitations and performance issues of OLEMI systems. |

| System | Description |
|---|---|
| **Series 2** | The Series 2 range was introduced by Network Rail as part of the National Electrification Programme to provide a reliable medium speed sagged simple OLE system which addressed the problems, limitations and performance issues of OLEMI systems.<br>Series 2 provides Energy TSI compliance for multiple pantographs as part of the Master Series catalogue. |
| **HS1** | Excluded from Scope of this Document |

Source: Mott MacDonald and Overhead Line Electrification for Railways 5th Edition 2018

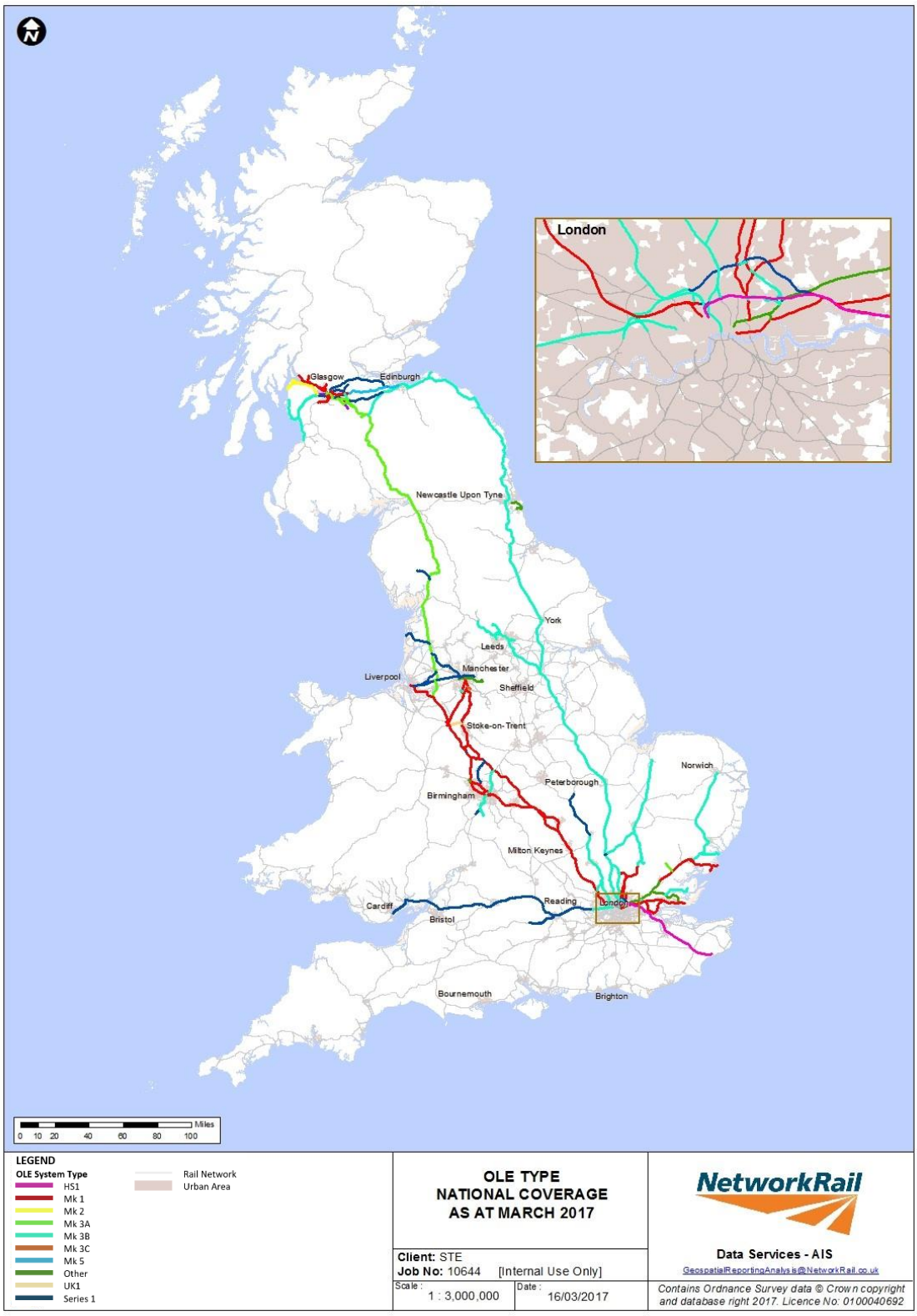
Table 2 sets out the approximate number of overhead line equipment structures deployed by Design Series and Network Rail region as at mid-calendar year 2019.

## Table 2: Overhead Line Equipment Design Series deployments

| | Overhead Line Equipment Design Series | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Region** / Structure Type | **Mark 3** | **Mark 1** | **UK1** | **Series 2** | **GE** | **Series 1** | **Mark 2** | **SCS** | **SICAT** | **Mark 5** | **Mark BB** | **Total** |
| **London & North Eastern** | **22,801** | **348** | **5,235** | **143** | **-** | **-** | **176** | **-** | **-** | **-** | **12** | **28,715** |
| Cantilever | 17,512 | 288 | 4,562 | 115 | - | - | 7 | - | - | - | 8 | 22,492 |
| Headspan | 4,363 | - | 100 | 2 | - | - | 7 | - | - | - | 4 | 4,476 |
| Mast | 292 | 17 | 67 | 14 | - | - | 156 | - | - | - | - | 546 |
| Portal | 634 | 43 | 506 | 12 | - | - | 6 | - | - | - | - | 1,201 |
| **Scotland** | **12,946** | **3,652** | **2,699** | **5,166** | **-** | **-** | **1,462** | **-** | **461** | **-** | **-** | **26,386** |
| Cantilever | 10,225 | 2,773 | 2,245 | 3,466 | - | - | 1,218 | - | 268 | - | - | 20,195 |
| Headspan | 815 | 133 | 2 | 38 | - | - | 3 | - | 1 | - | - | 992 |
| Mast | 1,501 | 4 | 48 | 1,258 | - | - | 9 | - | 23 | - | - | 2,843 |
| Portal | 405 | 742 | 404 | 404 | - | - | 232 | - | 169 | - | - | 2,356 |
| **South Eastern (East Anglia)** | **7,676** | **7,513** | **4,284** | **431** | **4,441** | **-** | **-** | **732** | **-** | **-** | **-** | **25,077** |
| Cantilever | 6,219 | 5,660 | 2,630 | 348 | 2,907 | - | - | 341 | - | - | - | 18,105 |
| Headspan | 360 | 97 | 37 | 1 | 74 | - | - | 5 | - | - | - | 574 |
| Mast | 53 | 29 | 97 | 35 | 74 | - | - | 11 | - | - | - | 299 |
| Portal | 1,044 | 1,727 | 1,520 | 47 | 1,386 | - | - | 375 | - | - | - | 6,099 |
| **North West** | **7,249** | **4,538** | **4,639** | **6,096** | **1,721** | **-** | **55** | **-** | **-** | **-** | **-** | **24,298** |
| Cantilever | 4,571 | 2,598 | 2,216 | 4,782 | 910 | - | 46 | - | - | - | - | 15,123 |
| Headspan | 664 | 7 | 54 | 19 | 1 | - | - | - | - | - | - | 745 |
| Mast | 1,672 | 134 | 83 | 1,073 | 62 | - | 2 | - | - | - | - | 3,026 |
| Portal | 342 | 1,799 | 2,286 | 222 | 748 | - | 7 | - | - | - | - | 5,404 |
| **Great Western** | **1,948** | **413** | **6** | **252** | **-** | **5,465** | **-** | **-** | **-** | **-** | **-** | **8,084** |
| Cantilever | 840 | 244 | 4 | 131 | - | 4,187 | - | - | - | - | - | 5,406 |
| Headspan | 102 | 62 | - | 48 | - | 328 | - | - | - | - | - | 540 |
| Mast | 102 | 14 | - | 55 | - | 183 | - | - | - | - | - | 354 |
| Portal | 904 | 93 | 2 | 18 | - | 767 | - | - | - | - | - | 1,784 |
| **North West (Midlands Lines)** | **1,942** | **5,274** | **235** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **7,451** |
| Cantilever | 1,600 | 3,430 | 175 | - | - | - | - | - | - | - | - | 5,205 |
| Headspan | 60 | 45 | - | - | - | - | - | - | - | - | - | 105 |
| Mast | 16 | 138 | 7 | - | - | - | - | - | - | - | - | 161 |
| Portal | 266 | 1,661 | 53 | - | - | - | - | - | - | - | - | 1,980 |
| **South Eastern (Kent & Sussex)** | **152** | **37** | **10** | **-** | **-** | **-** | **-** | **-** | **-** | **60** | **-** | **259** |
| Cantilever | 79 | 20 | 2 | - | - | - | - | - | - | 28 | - | 129 |
| Headspan | 31 | 3 | - | - | - | - | - | - | - | 22 | - | 56 |
| Mast | 39 | 13 | 1 | - | - | - | - | - | - | 10 | - | 63 |
| Portal | 3 | 1 | 7 | - | - | - | - | - | - | - | - | 11 |
| **Grand Total** | **54,714** | **21,775** | **17,108** | **12,088** | **6,162** | **5,465** | **1,693** | **732** | **461** | **60** | **12** | **120,270** |

Source: Network Rail

**Figure 1: Network Rail OLE Type National Coverage**




Source: Network Rail

The variety and type of OLE structure in current operational use within Network Rail is shown in the sample photographs below (reproduced by kind permission of Network Rail). This highlights the unique challenges associated with the potential fitment of small cells and/or wireless antenna to OLE structures, and the challenges of bracket and fixtures design.

**Photo 1: Series 2 UKMS Two Track Cantilever**

Source: Network Rail

**Photo 2: GEFF Portal**

Source: Network Rail

## Photo 3: Series 2 UKMS Single Track Cantilevers

Source: Network Rail

## Photo 4: Mark 1 Portal


Source: Network Rail

## Photo 5: Series 1 Portal

Source: Network Rail

## Photo 6: Series 2 UKMS Two Track Cantilever

Source: Network Rail

## Photo 7: Mark 3 Balance Weight Anchor

Source: Network Rail

## Photo 8: Series 1 Portal

Source: Network Rail

### Photo 9: UK1 Portal

Source: Network Rail

### Photo 10: Series 2 / UKMS Single Track Cantilever

Source: Network Rail

Prior to considering detailed requirements, it is also useful to confirm some standard OLE system terminology. Figure 2 below illustrates several of the key terms relating to OLE.

**Figure 2: OLE System Terminology**

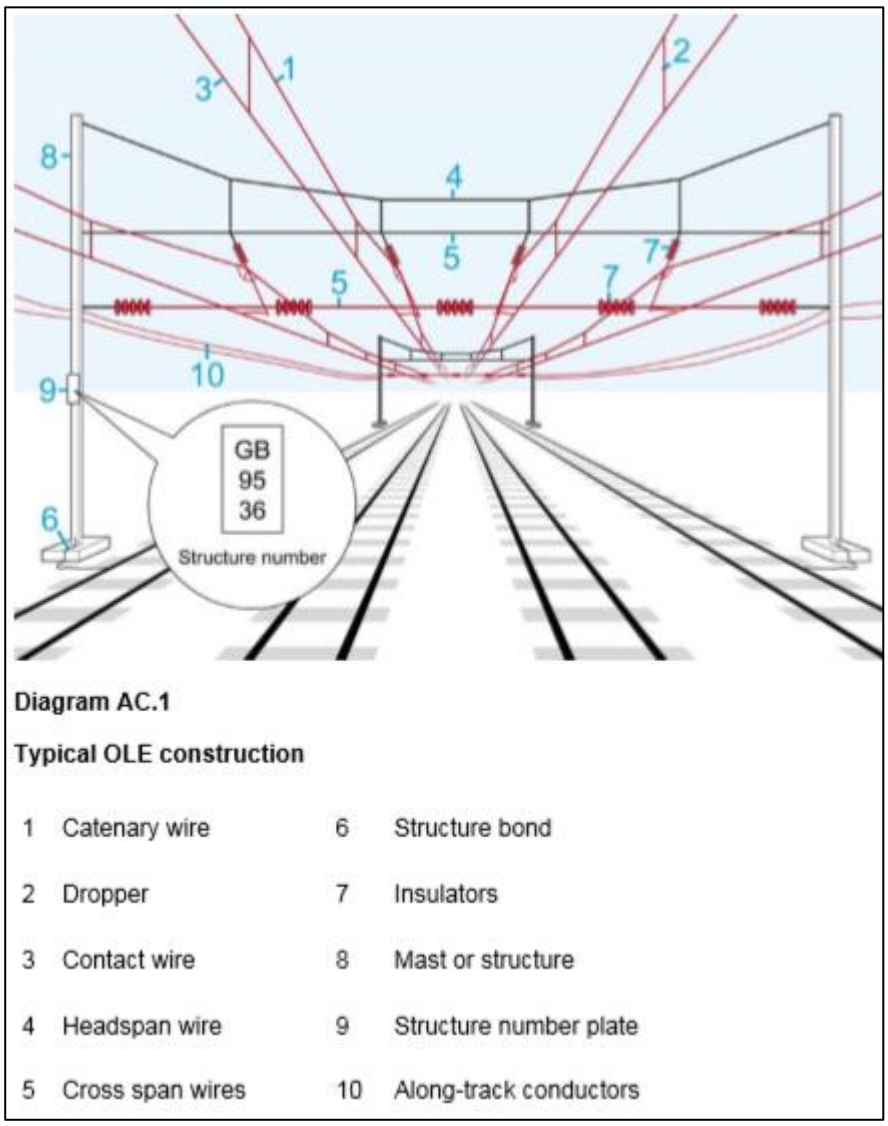



**Diagram AC.1**

**Typical OLE construction**

| | | | |
|---|---|---|---|
| 1 | Catenary wire | 6 | Structure bond |
| 2 | Dropper | 7 | Insulators |
| 3 | Contact wire | 8 | Mast or structure |
| 4 | Headspan wire | 9 | Structure number plate |
| 5 | Cross span wires | 10 | Along-track conductors |

Source: GERT8000-AC Rule Book Module AC

# 3 Part A – Physical Mounting Considerations

The safe position and mounting of equipment on an OLE structure requires a number of inter-related factors to be considered, such as:

- Equipment weight, size and proposed height.
- Equipment positioning - electrical clearances to exposed live parts of the OLE system and mechanical clearances to rolling stock operating on the route.
- Impact of additional load on OLE structure and its foundation.
- Effect of wind and understanding of deflection limits affecting the OLE structure.
- Cables and Cable Containment connecting the equipment to peripheral equipment associated with the wider technological solution (backhaul, power).

These aspects are discussed in the following sections.

## 3.1 General Safety Requirements

Any small cells and/or wireless antenna (“the equipment”) to be mounted on an OLE structure shall be positioned in a manner which does not interfere with the safe operation of the railway.

All equipment shall be securely fastened to the OLE structure in such a manner as to ensure it cannot become loose or detached and cause damage to passing rolling stock, cause injury to members of the public or track workers.

## 3.2 Electrical Clearance

### 3.2.1 Requirements

Any small cells and/or wireless antenna (“the equipment”) proposed to be mounted on an OLE structure shall be compliant with the minimum electrical clearance requirements defined within the relevant standards, in particular:

- The Electricity At Work Regulations 1989.
- Railway Group Standard GL/RT1210: AC Energy Subsystem and Interfaces to Rolling Stock Subsystem.
- Network Rail Company Standard NR/L2/ELP/27715 Module 04: Electrical and Mechanical Clearances and Separation.
- BS EN 50122-1:2011+A1:2011: Railway applications - Fixed installations - Electrical safety, earthing and the return circuit - Part 1: Protective provisions against electric shock.

The electrical clearance dimensions published in Table 5 of Railway Group Standard GL/RT1210 shall be taken as minimum.

The electrical clearance between any equipment mounted on an OLE structure and the exposed live parts of the OCL shall be maximised so far as is reasonably practicable. It shall not be the default to use ‘normal’ or ‘minimum’ clearance values as published

Where it is not reasonably practicable to provide electrical clearances in the ‘normal’ category, GL/RT1210 clause 3.1.7.3 permits the use of reduced clearances where justified by a Risk

Assessment compliant with CSM-RA and any appropriate safety measures identified by the risk assessment are implemented.

### 3.2.2 Rationale

There will be restrictions on where the equipment can be physically located on an OLE structure, this is governed by the vicinity of the exposed live parts of the OCL.

### 3.2.3 Guidance

A number of standards exist which define the electrical clearances to exposed 25kV OCL live parts which should be met as a minimum.

The Electricity At Work Regulations 1989 is the overarching mandatory legislation which shall be complied with. The aim of the Electricity at Work Regulations 1989 is to prevent death or personal injury to any person from electrical causes in connection with work activities.

Railway Group Standard GL/RT1210 consolidates existing standards and practices for 25kV AC electrification, and mandates requirements in line with EU requirements for interoperability and migration towards a uniform system for 25kV AC electrified railway on Network Rail controlled infrastructure, while continuing to provide compatibility with existing rolling stock.

RSSB Guidance Note GL/GN1610: Guidance on AC Energy Subsystem and Interfaces to Rolling Stock Subsystem gives guidance on interpreting the requirements of Railway Group Standard GL/RT1210. It does not constitute a recommended method of meeting any set of mandatory requirements.

Network Rail Company Standard NR/L2/ELP/27715 Module 04 “Electrical and Mechanical Clearances and Separation” contains the requirements to be complied with when designing or evaluating railway subsystem designs that impact on the Overhead Contact System (OCS) and pantograph clearances at over line and lineside structures and standing surfaces to meet legislative requirements and to achieve safety, economy and performance.

BS EN 50122-1:2011+A1:2011 Railway applications - Fixed installations - Electrical safety, earthing and the return circuit - Part 1: Protective provisions against electric shock specifies requirements for the protective provisions relating to electrical safety in fixed installations associated with AC traction systems and to any installations that can be endangered by the traction power supply system.

The potential locations for mounting of equipment will also vary between different OLE structure types and arrangement of the OCL.

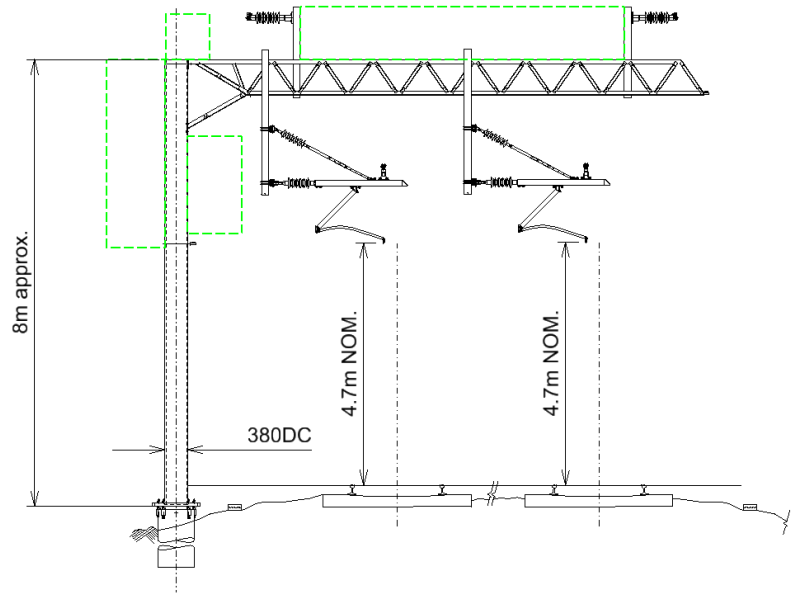
It should be noted that this consideration only identifies potential safe locations on a particular type of structure to mount equipment. Other considerations may deem some of these potential areas unsuitable and discounted, e.g. due to height/maintenance access etc. Another factor which will determine suitability of potential locations is the technological solution and minimum/optimum height for the proposed solution and communication with train-borne antenna.

### 3.2.4 Scenarios

Figure 3 to Figure 12 indicate potential safe locations (the green hashed areas) to mount equipment for a sample of OLE structure types. These diagrams are indicative only and not to scale. Specific dimensions should be obtained from the relevant OLE master drawings.

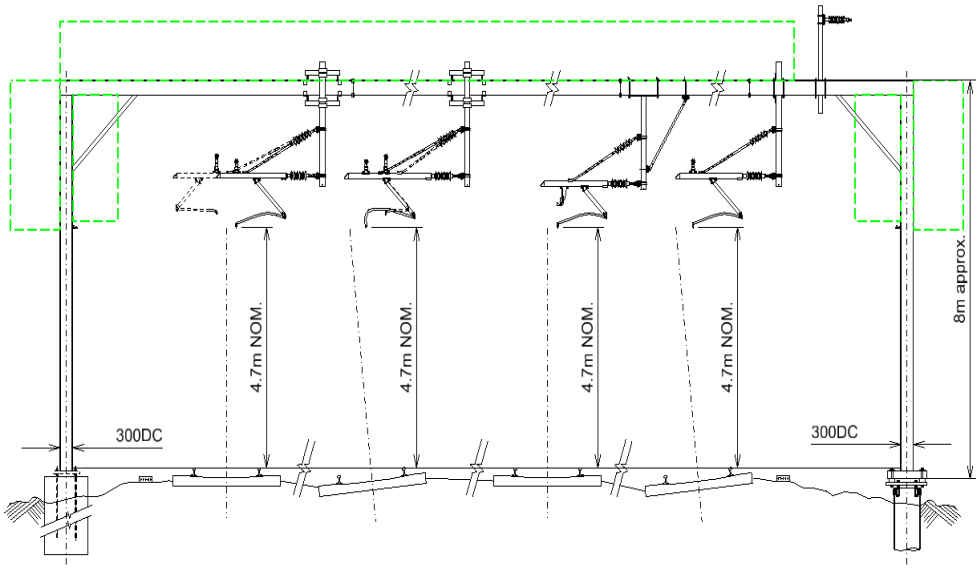
It should be noted that the identification of potential safe locations is only from an electrical clearance from live parts of the OLE perspective. Other factors may deem that some or all of these locations are not suitable for use.

**Figure 3: Series 2 UKMS Two Track Cantilever (TTC) Arrangement With Possible Safe Attachment Areas**



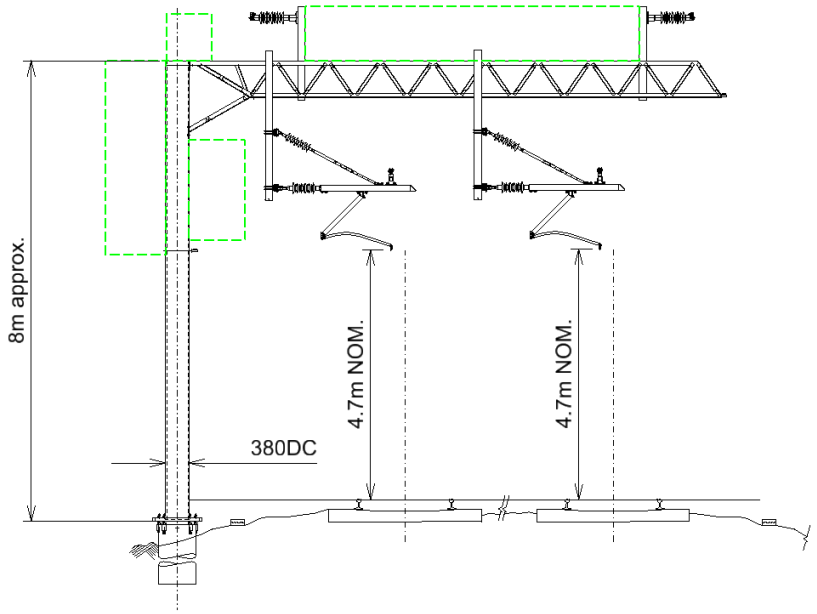

Source: Mott MacDonald & Network Rail

**Figure 4: Series 2 UKMS Portal arrangement Showing Possible Attachment Locations**



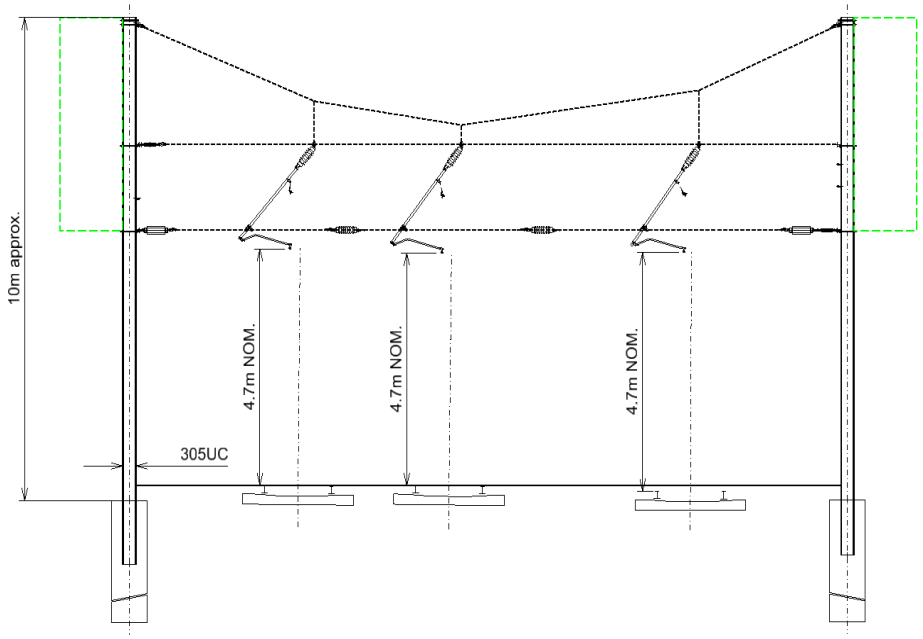

Source: Mott MacDonald & Network Rail

**Figure 5: Series 2 UKMS Two Track Cantilever Arrangement Showing Possible Attachment Locations**



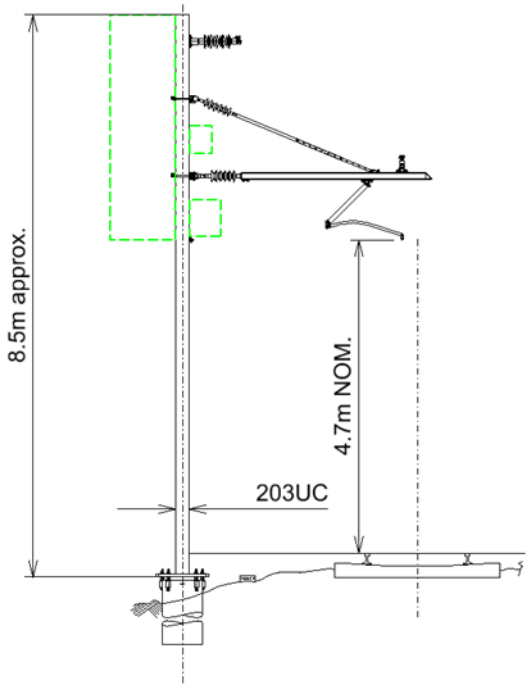

Source: Mott MacDonald & Network Rail

**Figure 6: Mark 3B Head-Span Arrangement With Possible Safe Attachment Areas**



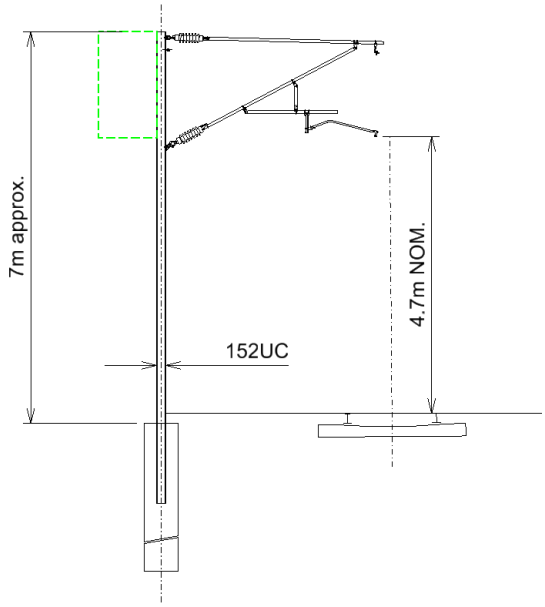

Source: Mott MacDonald & Network Rail

**Figure 7: Series 2 UKMS Single Track Cantilever Arrangement showing possible attachment areas**



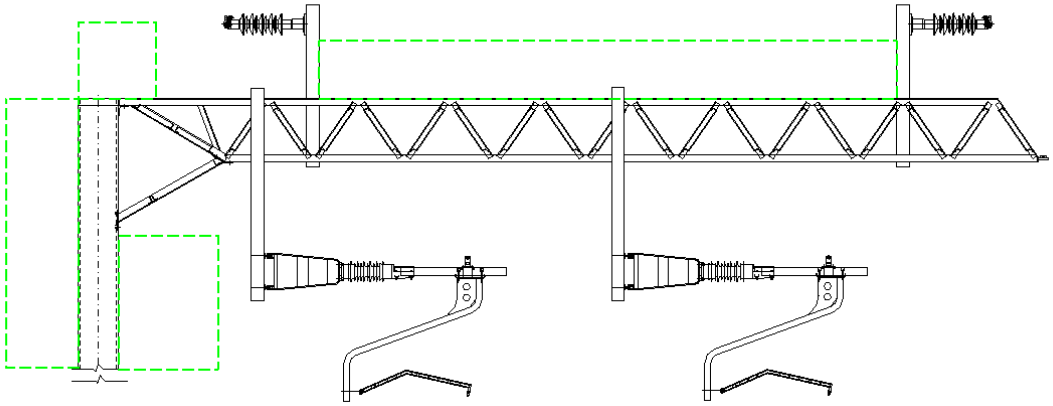

Source: Mott MacDonald & Network Rail

**Figure 8: Mark 3B Single Track Cantilever Arrangement Showing Possible Attachment Areas**



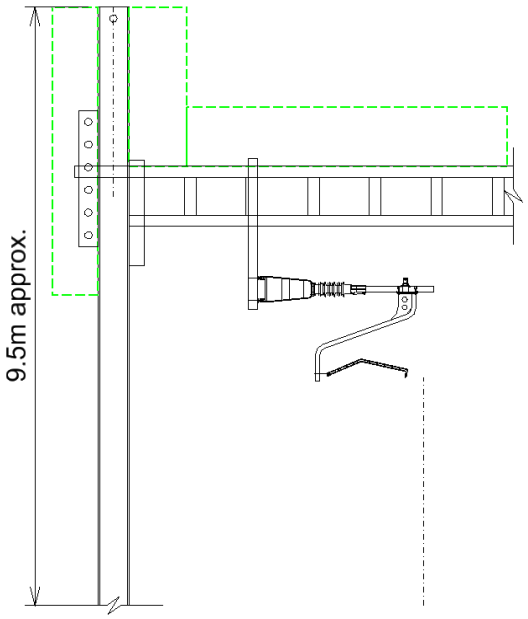

Source: Mott MacDonald & Network Rail

**Figure 9: Single Insulated Cantilever TTC Arrangement Showing Possible Attachment Locations**



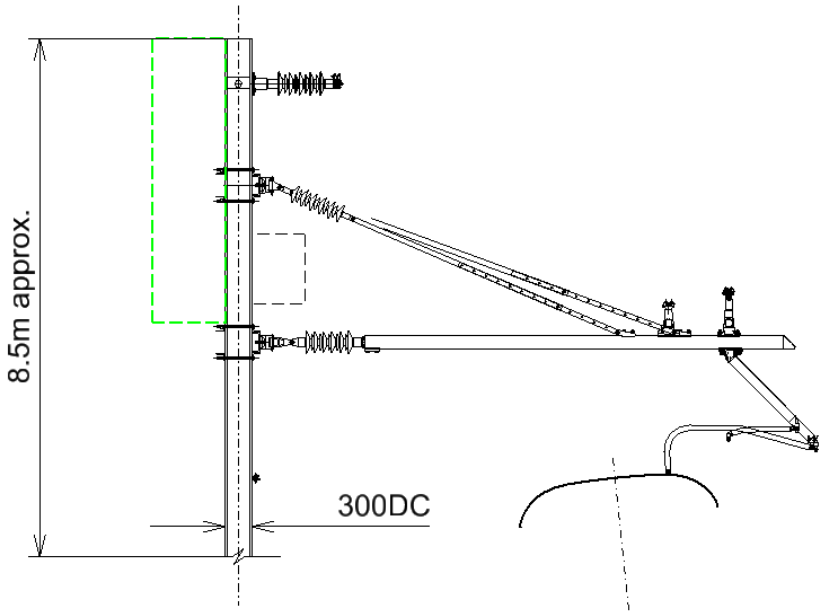
Source: Mott MacDonald & Network Rail

**Figure 10: Series 1 Style TTC/Portal Arrangement Showing Possible Attachment Locations**



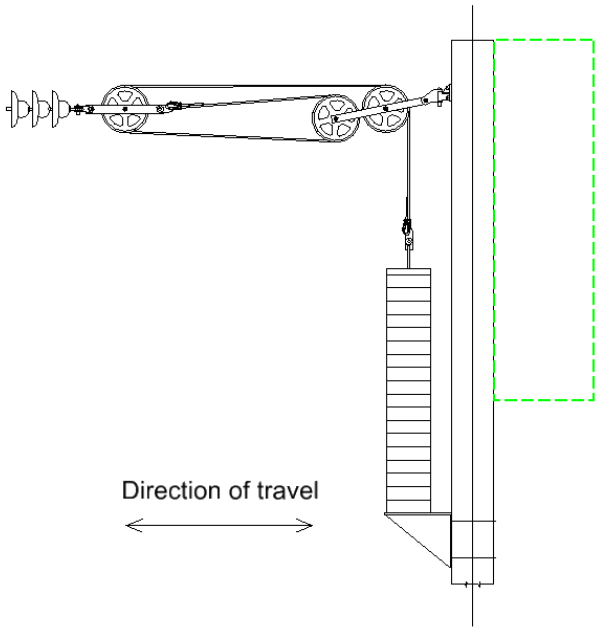

Source: Mott MacDonald & Network Rail

**Figure 11: Series 2 UKMS Twin Cantilever Arrangements Showing Possible Attachment Locations**




Source: Mott MacDonald & Network Rail

**Figure 12: Mark 3 Balance Weight Anchor Showing Possible Attachment Locations**




Source: Mott MacDonald & Network Rail

## 3.3 Mechanical Clearances

### 3.3.1 Requirements

Any equipment to be mounted on an OLE structure shall be positioned in a manner which does not interfere with the safe operation of the railway.

There shall be adequate clearances between rolling stock and any equipment mounted on the adjacent OLE structures. This shall be achieved through application of the gauging principles and requirements defined within the relevant standards, in particular:

- GE/RT8073: Requirements for the Application of Standard Vehicle Gauges.
- GE/RT8273: Assessment of Compatibility of Rolling Stock and Infrastructure - Gauging and Stepping Distances.
- GI/RT7073: Requirements for the Position of Infrastructure and for Defining and Maintaining Clearances; and
- GM/RT2173: Requirements for the Size of Vehicles and Position of Equipment.

### 3.3.2 Rationale

There will be restrictions on where equipment can be physically located on an OLE structure in terms of clearance with rolling stock operating on the route.

### 3.3.3 Guidance

RSSB GE/GN8573: Guidance on Gauging and Platform Stepping Distances sets out information and advisory material in support of the application of the various Railway Group Standards covering gauging. It also provides background material on the original derivation of the vehicle gauges in common use. The document forms a compendium of knowledge and advice relating to all aspects of gauging.

Railway Group Standard GE/RT8073: Requirements for the Application of Standard Vehicle Gauges defines standard vehicle gauges and the associated application rules for rolling stock and for infrastructure (in particular clause 4.1.3 Clearances).

Railway Group Standard GIRT7073: Requirements for the Position of Infrastructure and for Defining and Maintaining Clearances mandates requirements for positioning infrastructure and maintaining the position of track relative to infrastructure to achieve gauge compatibility with rolling stock. All proposed equipment positions shall be assessed for, and achieve, gauge compatibility with rolling stock, in accordance with these requirements.

Railway Group Standard GE/RT8273 Assessment of Compatibility of Rolling Stock and Infrastructure – Gauging and Stepping Distances – this document sets out specific requirements and responsibilities for the assessment of gauge compatibility (and stepping distances) between rolling stock and infrastructure.

Before any new or modified infrastructure or vehicle is put into use on a specific route, or the use of infrastructure or vehicles is changed, it is essential that the change is assessed to ensure that technical compatibility between assets is determined. Rail Industry Standard RIS-8270-RST: Route Level Assessment of Technical Compatibility between Vehicles and Infrastructure sets out requirements and responsibilities for the assessment of technical compatibility at route level for vehicles and infrastructure.

## 3.4 Structural Condition

### 3.4.1 Requirements

An assessment of the OLE structure shall be undertaken to ensure the structure is free from defects, is structurally sound and fit for purpose.

### 3.4.2 Rationale

Before any equipment is attached to an OLE structure, the structural integrity must be established to ensure that the structure is fit for purpose, has no inherent defects and can support the proposed loadings to ensure the overall safety of the operational railway.

### 3.4.3 Guidance

Network Rail undertake OLE structural examinations in accordance with NR/L3/ELP/27237/OLE/B01: Overhead Line Work Instructions, in particular the following:

- NR/OLE B01 Non-intrusive ground level visual inspections
- NR/OLE B06 Visual inspection of OLE structures
- NR/OLE B13 OLE asset condition assessment

The frequency of the structural examinations is specified within NR/L2/ELP/21087: Specification of maintenance frequency and defect prioritisation of Overhead Line Electrification Equipment

Network Rail hold an OLE asset register which will contain information from the structural examinations regarding identified defects.

The Network Rail Professional Head of Contact Wire Systems shall be contacted to provide the current condition of the structures required for mounting the equipment.

## 3.5 Weight Loading – Impact on OLE Structure and Foundation

The additional loading associated with any proposed equipment, cabling and cable containment to be mounted on an OLE structure shall not have a detrimental effect on the integrity of the overhead line support structure and its foundation.

The effect of the additional loading imposed on an OLE structure shall remain within defined acceptable limits for structural safety, and assessed in line with applicable standards, in particular:

- BS EN 1990 Eurocode 0: Basis of structural design (and associated national annex)
- BS EN 1991 Eurocode 1. Actions on structures (and associated national annex)
- NR/L2/CIV/073 Design of Overhead Line Structures (clause 8)
- NR/L2/CIV/003/F1990 Technical Design Requirements for BS EN 1990
- NR/L2/CIV/003/F1991 Technical Design Requirements for BS EN 1991

### 3.5.1 Rationale

Any additional load imposed on a structure requires assessment to ensure that the integrity of the structure and its associated foundation is not compromised or imposes no risk to personnel, members of the public and the operational safety of the railway.

### 3.5.2 Guidance

NR/L2/CIV/073: Design of Overhead Line Structures provides overall requirements regarding basis of design, use of structural Eurocodes, the limit state philosophy, actions to be applied, partial factors and load combinations.

Consideration needs to be given on the weight and loading associated with any infrastructure required to supply antennas and any other equipment required to be used, this may include such items as:

- Cable containment and support structures
- Antenna feeders
- Power cables
- Fibre Optic cables
- Number of antennas
- Mast-mounted Power Supplies

## 3.6 Wind Loading and Deflection – Impact on OLE Structure/Foundation

### 3.6.1 Requirements

The effect of wind and possible twisting moments and deflection of any equipment proposed to be mounted on an OLE structure shall be assessed against the specific OLE structure type and proposed antenna profile size, weight, height and orientation.

The wind force on an OLE structure with the equipment mounted shall be calculated in accordance with the requirements within NR/L2/CIV/072: Wind Loading of Overhead Line Equipment and Structures, in particular Equation 43 within clause 8.6.

The aerodynamic effects of a running train on the OLE structure once additional loading has been added shall be considered in accordance with NR/L2/CIV/073 Clause 7.9: Special Actions.

NR/L2/CIV/073: Design of Overhead Line Structures clause 5.4 shall be complied with to establish the limits for allowable movements of the foundation, structure and contact wire, taking into account the impact of the additional equipment mounted on the structure, to ensure compatibility with the overall performance of the overhead line system.

Deflections shall be checked in accordance with NR/L2/CIV/072: Wind Loading of Overhead Line Equipment and Structures clause 9 and the criteria given in NR/L2/CIV/073.

### 3.6.2 Rationale

The effect of wind forces and the aerodynamic effect of a passing train requires consideration, particularly concerning the potential for movement and deflection of the antenna, associated equipment and the overall integrity of the structure and its foundation.

### 3.6.3 Guidance

NR/L2/CIV/073: Design of Overhead Line Structures provides overall requirements regarding basis of design, use of structural Eurocodes, the limit state philosophy, actions to be applied, partial factors and load combinations.

NR/L2/CIV/072: Wind Loading of Overhead Line Equipment and Structures provides requirements for calculating wind load and deflection on all elements of the overhead line and its support structures.

NR/L2/CIV/072: Wind Loading of Overhead Line Equipment and Structures and NR/L2/CIV/073 form part of a suite of Civil Engineering Electrification standards for overhead line equipment. These standards implement the structural Eurocodes EN 1990 to EN 1999 for structural design of Overhead Line Equipment structures including foundations.

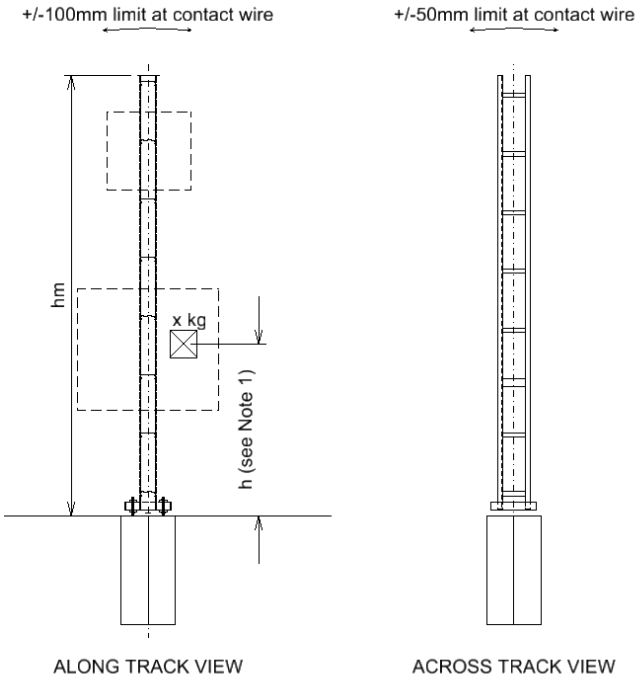
From the wind loadings point of view, the smaller the equipment, the closer it is to the OLE structure centre line and the lower down the structure the equipment is placed will assist with the reduction of any bending or twisting moments.

Mobile Network Operators (MNO) typically require a deflection criterion of no more than 0.5 degrees associated with the mounted antenna. The rail industry applies a deflection criteria in terms of millimetres of movement of a structure rather than degrees of movement of the antenna itself. This difference occurs due to the requirement for pointing accuracy versus OLE stability, respectively.

### 3.6.4 Scenarios

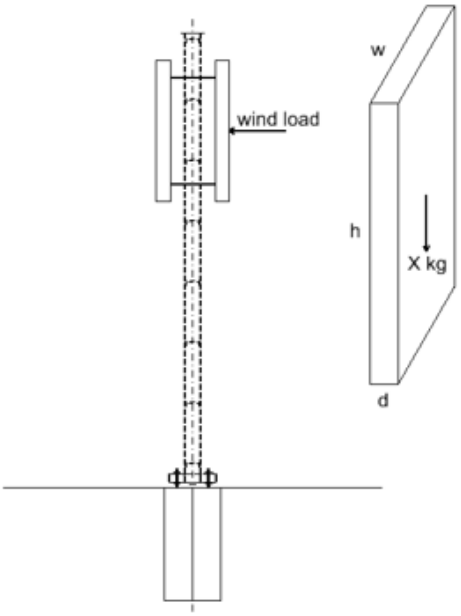
Weight, physical dimensions and mounting methods are all very important, as is the wind loading effect introduced by the technology to be mounted. Figure 13 to Figure 15 show the deviations allowed and offer some potential concepts of weight and wind loading effects.

**Figure 13: Showing Maximum Lateral and Longitudinal Movement Allowed**




Source: Mott MacDonald

**Figure 14: Indicating Wind Loading and Possible Wind Disturbance from Passing Rolling Stock**

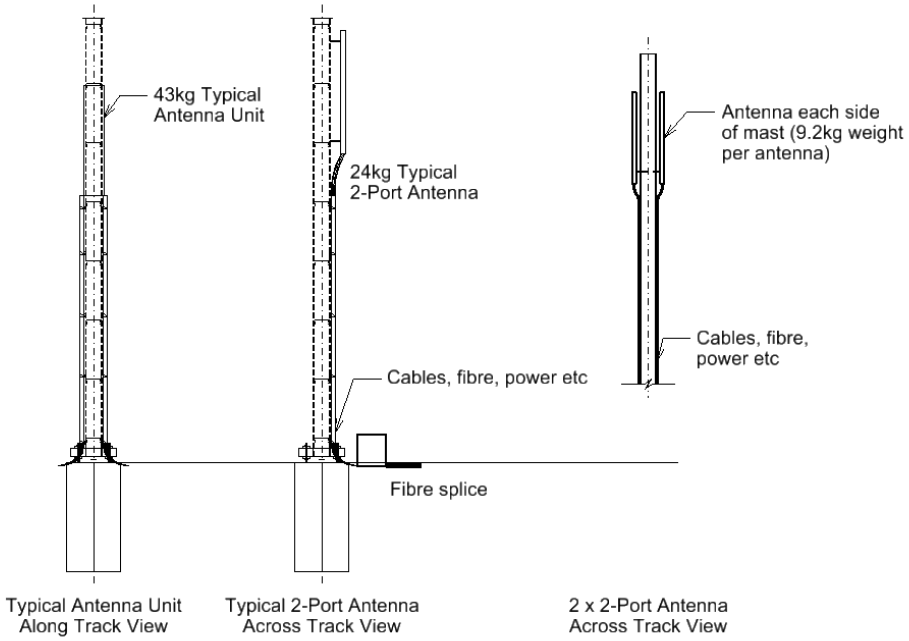



Source: Mott MacDonald

Notes to Figure 14:

1. Across track and along track loads in accordance with NR/L2/CIV/072.
2. Wind loading assessments on high speed lines may be required.
3. NR/L2.CIV/073 Clause 7.9 Aerodynamic effects of running trains are small for normal conductor and support arrangements and should not be considered where pressure changes can readily equalise across the structure. Aerodynamic effects may require further consideration for large flat-sided structures.

**Figure 15: Indicative Antenna Types and Weights and possible Scenarios with Reference to Cables and Mounting of Antennas**




Source: Mott MacDonald

### 3.6.5 Deflection calculations for range of typical antenna size/weight

Table 3 presents the deflection calculations on a potential worst-case scenario utilising one of the currently largest and heaviest antenna that may be utilised (encompassing 5G/Massive MIMO capability).

The calculations show that the structures would not flex more than the maximum movement as set out in standards. Many other antennas and systems will be a smaller footprint and will weigh less, therefore reducing the loading effects of mounting additional equipment to the OLE structures

In the calculation table below a worst-case scenario has been used, and the H Beam structure based on the Universal Columns (UC) series is one of the oldest and smallest still in use across the UK Rail network today.

Universal columns are the most often used section for structural steel purposes. Due to their section shape, they are often called “I-sections” or “H-sections”. Unlike a universal beam, the UC's width is roughly equal to their depth. For example, a 152 UC 23 is 152 mm wide and 152 mm deep.

The heights of the current OLE mast structures range between 7.5 to 10 metres and the contact wire is generally set to 4.7 Metres. It is considered in most cases the antennas to be utilised will be mounted centrally aligned to the contact wire height so that the antennas will be able to fire down onto the train roof mounted antennas currently in use across UK Rail Rolling Stock and the example calculations in Table 3 reflect this.

To illustrate the variances, the example calculations in Table 3 refer to the following structure types:

- Example 1: Historic structure project specific, SCS Range, but still in use on UK Railways (Smallest Mast in use)
- Example 2: Master Series (Series 2)
- Example 3: Master Series (Series 2)

Other structures are available, such as used on GWR, “Type 22” 220x220x71.5 (i.e. 220mm x 220mm at 71.5kg/m) H-beam at 7 metres tall, whilst a mast supporting a double catenary span is a 350x350mm tubular structure.

**Each case shall be considered on its individual profile and performance and shall be verified and agreed by Network Rail.**

**The calculations are intended for guidance only and are to show the logic behind the requirements for deflections within the standards already quoted.**

**Table 3: Sample Deflection Calculation for current ‘worst’ case antenna**

| **Antenna Assumptions** | **Examples & Notes** |
|---|---|
| Unit Profile: 369 W x 1999 H x 196 D mm, Unit Mass (including fixings): 43kg, Mounting height of Unit: 4.7 metres (centred around contact wire height) | Example 1: Deflection on 152x152x23UC mast (Historic SCS Range) from equipment wind load was calculated at 44.55mm. |
| | Example 2: Deflection on 203x203x46UC mast (Master Series 2) from equipment wind load was calculated at 11.50mm. |
| | Example 3: Deflection on 356x368 x129UC mast (Master Series 2) (anchor orientation) from equipment wind load was calculated at 0.44mm. |
| | **Notes:**<br>● Deflection checks for OCS structures was conducted at the Serviceability Limit State checks as specified in NR/L2/CIV073. For the maximum contributions from any Telecoms equipment, an assessment at Load Case B – Maximum wind with co-existent temperature is appropriate – using a peak wind velocity and 3-year return period wind = 66% of 50-year return period of wind load.<br>● Any wind load effects will vary considerably based on the factors as specified in EN 1991 (Euro-Codes Actions on Structures) and NR/L2/CIV073 (Design of Overhead Line Structures) based on factors including national location and local terrain conditions.<br>● Refer to NR/L2/CIV072 for explanation of the calculation process. |

Source: Mott MacDonald

The above calculation show that the deflections are within the pass parameters outlined in the standards.

# 4 Part B – Design Assurance

## 4.1 Requirements

Any change or enhancement to Network Rail infrastructure assets shall comply with the following standards as a minimum to provide the required level of design assurance during the development and implementation of potential solutions:

- The Network Rail GRIP process as defined within NR/L2/INI/P3M/101: Governance for Railway Investment Projects (GRIP) - Projects (formerly NR/L1/INl/PM/GRIP/100) and associated standards referenced within.
- NR/L2/INI/02009: Engineering Management for Projects.
- NR/L2/CIV/003: Technical Approval of design, construction and maintenance of Civil Engineering Infrastructure.
- NR/L2/TEL/30022: Engineering Assurance Arrangements for Communications Engineering Schemes and services.
- NR/L2/ELP/27311: Engineering Assurance Requirements for Design and Implementation of Electrical Power.
- NR/L3/ELP/27406 Engineering Deliverables for Electrical Power Asset Design.

Before any new or modified infrastructure is put into use on a specific route, or the use of infrastructure is changed, it is essential that the change is assessed to ensure that technical compatibility between assets is determined. Rail Industry Standard RIS-8270-RST: Route Level Assessment of Technical Compatibility between Vehicles and Infrastructure sets out requirements and responsibilities for the assessment of technical compatibility at route level for vehicles and infrastructure and shall be complied with for the proposed modification to OLE structures.

## 4.2 Rationale

Any proposed modification or change to infrastructure shall be developed in accordance with Network Rail Standards and assurance demonstrated that the proposed modification is fit for purpose and safe for introduction onto Network Rail infrastructure.

## 4.3 Guidance

Governance for Railway Investment Projects (GRIP) describes how Network Rail manages and controls projects that enhance or renew the national rail network.

NR/L2/INI/02009: Engineering Management for Projects seeks to align Network Rail engineering practices with UK and EU legislative instruments specifically the Construction (Design and Management) Regulations and the Common Safety Methods for Risk Evaluation and Assessment. This issue also seeks to develop the roles, responsibilities, accountabilities and competence of key engineering roles, many of which contribute the discharge of legal obligations under the specific legislative instruments.

Individual standards exist for the engineering assurance processes to be followed for each discipline.

# 5 Part C – Installation Considerations

## 5.1 Installation Considerations

### 5.1.1 Requirements

Any organisation wishing to undertake construction work on Network Rail infrastructure shall hold a Principal Contractors Licence in accordance with NR/L2/INl/CP0070: Principal Contractor Licensing Scheme.

All construction works on Network Rail infrastructure, in the vicinity of 25kV ac electrified lines, shall be undertaken in a safe manner in compliance with the relevant standards, in particular:

- Health and Safety at Work etc Act 1974.
- Management of Health and Safety At Work Regulations 1999.
- Electricity at Work Regulations 1989.
- The Construction (Design and Management) Regulations 2015.
- The Work at Height Regulations 2005.
- GE/RT8000 (The Rule Book): and all associated Modules and Handbooks.
- Network Rail Health and Safety Management System (HSMS).
- NR/L3/ELP/29987: Working on or About 25 kV AC Electrified Lines.
- NR/L2/OHS/019: Safety of people at work on or near the line.
- NR/L2/OHS/133 Code of Practice for Planning and Delivering Safe Work.
- NR/L2/OHS/0044: Planning and managing construction work.
- NR/L3/OPS/303: Possession of the Line for Engineering Work Delivery Requirements.
- Railway Group Standard GL/RT1210: AC Energy Subsystem and Interfaces to Rolling Stock Subsystem.
- BS EN 50122-1:2011+A1:2011: Railway applications - Fixed installations - Electrical safety, earthing and the return circuit Part 1: Protective provisions against electric shock.

Return conductors shall be treated as high voltage equipment in relation to protective provisions against direct contact.

### 5.1.2 Rationale

To enable construction works on Network Rail Infrastructure to take place, contractors shall comply with relevant legislation and standards relating to safety, working on or near the line, track possessions and isolations of 25kV OLE.

To install equipment at height will also require specific competencies and training in compliance with the Working at Height Regulations.

### 5.1.3 Guidance

Working on or near the railway is strictly controlled and it is imperative that any organisation that wish to undertake any works in this environment are fully aware of the requirements upon themselves, their employees or other contractors under their control.

A number of tiers of health and safety legislation and standards exist:

- Health and Safety Legislation
  - Health and Safety at Work etc Act 1974.
  - Management of Health and Safety At Work Regulations 1999.
  - The Construction (Design and Management) Regulations 2015.
  - Electricity At Work Regulations 1989.
  - The Work at Height Regulations 2005.
- Working on Network Rail Infrastructure
  - GE/RT8000 (The Rule Book): and all associated Modules and Handbooks.
  - Network Rail Health and Safety Management System (HSMS).
  - NR/L2/OHS/019: Safety of people at work on or near the line.
  - NR/L2/OHS/133 Code of Practice for Planning and Delivering Safe Work.
- Working in the vicinity of 25kV ac electrification
  - NR/L3/ELP/29987: Working on or About 25 kV AC Electrified Lines.
  - Railway Group Standard GL/RT1210: AC Energy Subsystem and Interfaces to Rolling Stock Subsystem.
  - BS EN 50122-1:2011+A1:2011: Railway applications — Fixed installations — Electrical safety, earthing and the return circuit Part 1: Protective provisions against electric shock.
- Track Possessions
  - NR/L2/OHS/0044: Planning and managing construction work.
  - NR/L3/OPS/303: Possession of the Line for Engineering Work Delivery Requirements.

Early consideration of constructability during the conceptual planning and design stages is vital, with particular consideration given to:

- Track access
  - Normally via designated access positions such as road access, walking routes etc.
  - Via a station platform and designated walking routes.
  - Use of Road Rail systems.
  - All personnel utilised will require appropriate qualifications to undertake work.
- Need for Track Possessions
  - Possession planning to support installation works, noting lead time for track possessions.
- Need for Isolations
  - Current time required to obtain a planned isolation is around 12 weeks.
  - Short term isolations would be dealt with on a local basis with Network Rail.
  - Longer term requirements for regular or planned isolations.
  - The average cost for an isolation and track possession combined is currently approximately £25,000 per five kilometres of track. Note: This figure is an approximation; the information has been derived from consultation with Network Rail and will vary dependent upon the location and nature of each individual application.

## 5.2 Impact on Rail Operations

### 5.2.1 Requirements

The signal sighting assessment process, as defined within the following standards, shall be applied to assess whether the proposed modified OLE structure could affect signal sighting:

- RIS-0737-CCS: Signal sighting assessment requirements
- NR/L2/SIG/10157: Signal Sighting Assessment Process
- NR/L2/SIG/10158: Specification for signal sighting assessment

### 5.2.2 Rationale

An assessment of the impact of the modified OLE structure is required to ensure there is no impact on driver distraction or signal obscuration.

### 5.2.3 Guidance

Any item being fixed to an OLE structure within the railway boundary must consider the risk of train driver distraction and signal obscuration. The following examples (non-exhaustive) are areas for consideration:

- Luminosity/ Reflection of material and how it could affect a train driver passing by
- Size of product
- Lights emitting from product; (Both Static and Flashing)
- Colour of Product; (Not Red, Yellow or Green) Ideally a dull grey
- Reduction to visibility of train driver to sighting of lineside signs (signals, lineside information signs/boards)
- The item obscures a driver's view of the railway in front of them (but no signal is obscured)
- Reduction to visibility of train driver to sighting of level crossings.

Any equipment mounted at a railway station shall not obscure any signage or Information relating to the safe operation of the Railway. The following examples (non-exhaustive) are areas of consideration:

- Train Stop Boards
- GSM-R/Radio Channel Info Boards
- On platform monitors used for train despatch
- Illuminated signs relating to train despatch operations.

Consideration shall be given to potential distractions to lineside personnel, for example:

- The equipment shall not emit any warning or other sounds that may be mistaken for Train Horns, Portable Track Worker Safety Systems
- The location of the equipment shall not impede the ability of any maintainers to carry out their duties
- The equipment shall be positioned to ensure that it can be maintained without the need for Isolation of the OLE.

## 5.3 Environmental Considerations

It is considered that no major impacts will be made upon the local environment due to mounting to the OLE structures or attaching other structures to it including telecommunications equipment and associated antennas and backhaul sub-systems. Power and connectivity provision may have environmental impact, but these would be solution specific.

### 5.3.1 Ecology Studies

It is considered that no ecological studies need to be carried out for this type of work.

### 5.3.2 Societal Impacts

It is believed that there will be no major societal impacts concerning the mounting of antenna onto OLE structures.

### 5.3.3 Sustainability

Use of solar energy, and other possible alternative methods of energy, will in turn lead to a reduction in reliance on DNO supplies, leading to a subsequent reduction in carbon footprint. Further carbon reduction shall be achieved through the re-use of existing assets to mount telecommunications equipment, reducing the need to install separate lineside infrastructure/masts.

# 6 Part D – Electrical Considerations

## 6.1 Cabling and Cable Routes

### 6.1.1 Requirements

Any cable route works and/or electrical, data, co-axial and fibre cable installation shall comply with relevant standards concerning cable routeworks, environment, segregation and cable protection, in particular:

- IEEE Blue Book (Colour Book Series).
- NR/GN/TEL/30139: The Survey and Design of Telecoms Cable and Route.
- NR/GN/TEL/30140: Telecoms Cable Route Installation.
- NR/GN/TEL/30140: Guidance Note Telecommunications Cable Routes and Installation.
- EN 61537: Cable Management - Cable Tray Systems and Cable Ladder Systems.
- IEC 61386: Conduits systems for cable management.
- NR/L2/TEL/00014: Optical Fibre Telecommunications Cables.
- NR/L2/TEL/30160: Optical Fibre Network Design.
- BS EN 60825-2:2000: Safety of laser products: safety of optical fibre communications systems.
- EN 50122-1: Railway applications: Fixed installations. Protective provisions relating to electrical safety and earthing.
- EN 50124-1: Railway Applications - Insulation Coordination - Part 1: Basic Requirements - Clearances and Creepage Distances For All Electrical And Electronic Equipment.
- EN 50125-3: Railway Application - Environmental Conditions For Equipment - Part 3: Equipment For Signalling And Telecommunications.
- EN 50173: Information technology – Generic cabling systems.
- EN 60950-1: Information Technology Equipment - Safety - Part 1: General Requirements.
- EN 60950-21: Information Technology Equipment - Safety - Remote Power Feeding.
- EN 60950-22: Information Technology Equipment - Safety - Part 22: Equipment Installed Outdoors.
- EN 60966-1: Information Technology Equipment - Safety - Part 1: General Requirements Radio Frequency and Coaxial Cable Assemblies - Part 1: Generic Specification - General Requirements And Test Methods.
- EN 61643-21: Low Voltage Surge Protective Devices - Part 21: Surge Protective Devices Connected to Telecommunications And Signalling Networks - Performance Requirements And Testing Methods
- EN 61663-1: Lightning Protection - Telecommunication Lines - Part 1 - Fibre Optic Installations.
- IEC 62305: Protection Against Lightning.
- IEC 60794-3-10: Optical fibre cables Outdoor cables – Family specification for duct, directly buried and lashed aerial optical.

### 6.1.2 Rationale

The equipment mounted to an OLE structure may require connection to a power supply, coaxial and/or fibre connectivity to a lineside radio head end unit, and fibre cable connectivity to a backhaul network either directly or indirectly via the lineside radio head end unit. Suitable cable containment such as tray or conduits correctly installed and earthed to give protection against surges and lightning will also need to be considered.

### 6.1.3 Guidance

The actual cable route and cabling requirements will be dependent upon the developed solution.

## 6.2 Power Supply

### 6.2.1 Requirements

The power supplies required to support any proposed OLE mast mounted and associated lineside equipment shall comply with relevant standards, in particular:

- NR/GN/ELP/27315: Management of Power Supplies to Telecoms Equipment.
- NR/SP/TEL/30025: Standby Power Supply Requirements for Operational Telecoms Equipment.
- NR/L2/ELP/27311: Engineering Assurance Requirements for Design and Implementation of Electrical Power Engineering Infrastructure Projects.
- IEEE 1100: Recommended Practice for Powering and Grounding Electronic Equipment - IEEE Emerald Book (Colour Book Series).

### 6.2.2 Rationale

Any proposed OLE mast mounted and associated lineside equipment will require connection to a suitably rated external power supply if the equipment is not operated from an internal battery or solar power supply.

### 6.2.3 Guidance

The actual power supply requirements will be dependent upon the developed solution. The type of power supply required will materially depend upon the technologies used and or implemented and it will be part of the system design which is outside the scope of this document.

The following suggestions are included to assist in making an informed choice of power supply to suit the technology to be utilised:

- Harvest from OLE (Inductive, Voltage Transformers etc)
- UPS (Battery)
- Solar/Battery
- DNO
- Existing Power Supply(s).

## 6.3 Electromagnetic Compatibility (EMC)

### 6.3.1 Requirements

Any proposed OLE mast mounted and associated lineside equipment shall comply with relevant EMC standards, in particular:

- NR/L2/RSE/30041: Electromagnetic compatibility (EMC) assurance process.
- BS EN 50121:2006: Railway Applications – Electromagnetic Compatibility. Parts 1 – 5.
- NR/L1/RSE/30040: EMC Strategy for Network Rail.
- NR/L2//TEL/30003: Immunity Test Requirements for Lineside Communications Systems.
- NR/L2/TEL/31106: Overview of Electromagnetic Coupling Between Traction Systems and telecommunications Cables.
- NR/L2/TEL/31107: Limits and Test Methods of Induced Voltages on Telecommunications Cables due to Electrification Systems.
- NR/SP/TEL/50016: Methodology for the Demonstration of Compatibility with Telecommunications Systems.
- NR/L3/ELP/27406/MOD L: Engineering Deliverable Requirements for Electrical Power Design – Module L AC/DC Traction Power Supply Interfaces.
- Rail Industry Standard RIS-8270-RST: Route Level Assessment of Technical Compatibility between Vehicles and Infrastructure.

### 6.3.2 Rationale

The electromagnetic environment in which the equipment will need to operate is challenging and could impact on the EMC immunity requirements of the equipment and/or the radio transmission performance. In addition, the location of additional transmitting equipment closer to other railway systems than is the case at present, may impact on the EMC immunity requirements applicable to these systems. The effects on personal working near to or maintaining such equipment shall also be evaluated to ensure no injury can be caused and any intentional radiation is within the prescribed limits.

### 6.3.3 Guidance

All equipment used on or near the Railway shall be product approved and CE marked, demonstrating that the appropriate testing has been undertaken to demonstrate evidence of immunity to external EMC sources such as power surges and radiated interference. Any equipment must also comply with the relevant standards for emissions and as such, shall not cause interference to other railway systems or passing rolling stock.

As part of managing health and safety, employers need to control the risks in the workplace under the Management of Health and Safety at Work Regulations 1999, consider what might cause harm to people and take reasonable steps to prevent harm – this includes considering any risks arising from exposure to electromagnetic fields both radio frequency and magnetic fields generated from high voltage power systems.

In addition to EMC, the physiological effects of electromagnetic fields will require consideration, particularly in the context of access and maintenance, where the combination of emissive equipment at one location may affect the assessments which underpin the industry guidance on this subject which is covered in Rail Industry Guidance Note GLGN1620 “Guidance on the Application of the Control of Electromagnetic Fields at Work Regulations”.

ICNIRP is the International Commission on Non-Ionizing Radiation Protection and have published guidelines on maximum time and levels of exposure.

## 6.4 Earthing and Bonding

### 6.4.1 Requirements

Any proposed OLE mast mounted and associated lineside equipment shall comply with relevant earthing and bonding standards to protect personnel and the system from harm, in particular:

- BS 7430: Code of Practice for Earthing.
- IEEE 1100: Recommended Practice for Powering and Grounding Electronic Equipment - IEEE Emerald Book (Colour Book Series).
- GT/TDINT 100: Earthing & Equipotential Bonding of Telecoms Equipment.
- IEEE 81: Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System.
- NR/SP/ELP/21085: Design of Earthing & Bonding Systems for 25kV AC Electrical Lines
- NR/L2/ELP/27311: Engineering Assurance Requirements for Design and Implementation of Electrical Power Engineering Infrastructure Projects.
- BS EN 50122-1: Railway applications. Fixed installations. Protective provisions relating to electrical safety and earthing.
- BS EN 50122-1:2011 +A1:2011: Railway Applications – Fixed Installations – Electrical Safety, earthing and the return circuit – Protective provisions against electric shock.
- BS EN 62305: Protection against lightning.

### 6.4.2 Rationale

The main function of the earthing system shall be to protect personnel and equipment against hazards arising from inadvertent potential differences occurring between conductive components. The earthing system shall also be designed to avoid interference to equipment due to potential differences occurring during normal and abnormal operating conditions.

### 6.4.3 Guidance

Consideration will need to be given to how the mast mounted equipment is to be dealt with from an earthing and bonding perspective; particularly given the risk of earth faults on the traction system or lightning strikes, for example. There may be different requirements applicable to OLE masts which are part of different traction system configurations (e.g. with or without return conductors and in autotransformer-fed systems).

The actual earthing and bonding requirements will be dependent upon the developed solution.

# 7 Part E – Maintenance Considerations

## 7.1 Requirements

All maintenance work on equipment mounted on an OLE structure shall be undertaken in a safe manner in compliance with the relevant standards, in particular:

- Health and Safety at Work etc Act 1974.
- Management of Health and Safety At Work Regulations 1999.
- Electricity at Work Regulations 1989.
- The Work at Height Regulations 2005.
- GE/RT8000 (The Rule Book): and all associated Modules and Handbooks.
- Network Rail Health and Safety Management System (HSMS).
- NR/L3/ELP/29987: Working on or About 25 kV AC Electrified Lines.
- NR/L2/OHS/019: Safety of people at work on or near the line.
- NR/L2/OHS/133: Code of Practice for Planning and Delivering Safe Work.
- NR/L3/OPS/303: Possession of the Line for Engineering Work Delivery Requirements.
- Railway Group Standard GL/RT1210: AC Energy Subsystem and Interfaces to Rolling Stock Subsystem.
- BS EN 50122-1:2011+A1:2011: Railway applications — Fixed installations — Electrical safety, earthing and the return circuit Part 1: Protective provisions against electric shock.

Return conductors shall be treated as high voltage equipment in relation to protective provisions against direct contact.

## 7.2 Rationale

Maintenance of OLE mast mounted telecommunications equipment will require to be undertaken in a safe manner in compliance with relevant legislation and standards relating to safety, working on or near the line, track possessions and isolations of 25kV OLE.

## 7.3 Guidance

The key element of maintenance of any equipment mounted at height on an OLE structure and therefore in the vicinity of 25kV AC electrified lines is whether this can be done safely without an isolation.

Lineside locations where maintenance personnel can potentially come in to close proximity to live OLE shall, as a minimum, meet the clearances as set out in Railway Group Standard GL/RT1210 clause 2.2.1 and BS EN 50122-1:2011+A1:2011 clause 5.2.1, Figure 4.

To maintain equipment at height will also require specific competencies and training in compliance with the Working at Height Regulations.

In a Network Rail context, the mounting of equipment on OLE masts is typically reserved for equipment forming part of the traction power supply. Existing Electrical Control Room Instructions, working instructions and procedures support isolation of equipment for safe access to traction power and OLE equipment. The applicability of these existing instructions, procedures and practices to non-OLE equipment mounted on OLE structures will be required to ensure safety of personnel working on this equipment.

# 8 Part F – Product Approval Considerations

## 8.1 Product Approvals and Assurance

### 8.1.1 Requirements

Any change that could affect the compatibility between vehicles and Network Rail infrastructure shall comply with the Network Rail Assurance Panel processes defined within NR/L2/RSE/100.

Where a new or changed product is introduced as part of Network Rail Infrastructure, it shall be demonstrated that the product is safe, compatible, reliable, fit for purpose and does not export unacceptable risks to Network Rail infrastructure.

NR/L2/RSE/100/05: Product acceptance and change to Network Rail operational infrastructure shall be complied with to provide the required level of product assurance to Network Rail Assurance Panel (NRAP) which will allow the product to be accepted for use on or about Network Rail infrastructure.

### 8.1.2 Rationale

The fitment of equipment to OHLE structures is a change that requires consideration from two aspects:

- The effect on the OHLE system and compatibility between vehicles and OHLE structures containing this additional equipment, as well as considerations for installation and maintenance.
- New telecommunications technologies being implemented, which require product approval to demonstrate product is safe, compatible, reliable, fit for purpose and does not export unacceptable risks to Network Rail infrastructure.

### 8.1.3 Guidance

The Network Rail Assurance Panel processes defined within NR/L2/RSE/100 and its associated modules defines the assurance processes and framework to be followed for consideration of any change that could affect the compatibility between vehicles and Network Rail infrastructure, or where new or novel products are proposed to be introduced.

The fitment of small cells and/or wireless antenna onto OHLE structures requires assessment to demonstrate there is no adverse impact on the OHLE system and that the additional equipment does affect the compatibility between vehicles and Network Rail infrastructure, and the general safe operation of the railway. The choice of technological solution may involve the introduction of novel products/solutions which will also require product approval.

It is highly recommended that the Railways Innovation and Development Centre (RIDC) be involved and utilised to test new and or modified equipment in a “Safe Railways Environment” before attempting to gain acceptance for use in a live rail environment.

The RIDC site, located at Melton, Leicestershire, has been purpose-built to provide a safe environment which supports both high and low speed testing of vehicles and infrastructure using two separate test tracks: a high-speed facility between Melton Junction and Edwalton,

incorporating 13 miles of track up to 125mph – 11 miles of this with overhead line equipment – and a slow-speed test track from Old Dalby to Stanton Tunnel, with four miles of track up to 60mph.

## 8.2 Common Safety Method – Risk Assessment (CSM-RA)

### 8.2.1 Requirements

Commission Implementing Regulation (EU) 402/2013, as amended by Commission Implementing Regulation (EU) 2015/1136 of 13 July 2015 (the Regulation on a common safety method (CSM) for risk evaluation and assessment [or "the CSM RA"]) shall be complied with for all change that has been deemed 'significant'.

Given the novel nature of mounting telecommunications equipment to OHLE structures, it is envisaged that any future project would be deemed to be significant under CSM-RA.

### 8.2.2 Rationale

Given the novel nature of mounting telecommunications equipment to OHLE structures, it is envisaged that any future project would be deemed to be significant under CSM-RA. Therefore, compliance with CSM-RA will be required. This will also require appointment of Assessment Body.

### 8.2.3 Guidance

The Common Safety Method for Risk evaluation and Assessment (CSM-RA) defines a common European risk management process.

The original Commission Regulation (EC) No 352/2009 of 24 April 2009 introduced the requirement for CSM RA and was replaced by Regulation 402/2013 of 30 April 2013. This was in turn amended with Regulation 2015/1136 of 13 July 2015.

The CSM RA applies when any technical, operational or organisational change is being proposed to the railway system. A person making the change (known as 'the proposer') needs to firstly consider if a change has an impact on safety. If there is no impact on safety, the risk management process in the CSM RA need not be applied and the proposer must keep a record of how it arrived at its decision.

If the change has an impact on safety the proposer must decide on whether it is significant or not by using criteria in the CSM RA. If the change is significant the proposer must apply the risk management process as defined within CSM RA. If the change is not significant, the proposer is not obliged to apply the risk management process. The proposer must keep a record of how it arrived at its decision.

Even if its use is not required by law, the CSM RA represents good practice for assessing and managing risk, and as such the processes are suitable for building into a company's safety management system more generally.

RSSB Guidance Note GEGN8646: Guidance on the Common Safety Method for Risk Evaluation and Assessment is aimed at those who need to undertake an application of CSM RA and steps through the relevant risk management processes.

The ORR has also produced guidance (ORR Common Safety Method for risk evaluation and assessment Guidance on the application of Commission Regulation (EU) 402/2013 September 2018) on the application of the CSM RA:

# 9 Part G – Spectrum and Connectivity Considerations

## 9.1 The technological solution / selection / type of antenna

The proposed technological solution will drive the selection of appropriate antenna types/size/weights which in turn will influence the design of appropriate bracketry.

## 9.2 Spectrum Allocation and Usage

Spectrum allocation and availability will be critical to the operation of any train to shore and shore to train radio communication. It is outside the remit of this guidance note to offer any advice on this subject, however the following example spectrum types could be considered during design phases:

- Licensed
- Unlicensed
- Light Licence
- Use of Existing Frequencies.

## 9.3 Radio/Wireless Propagation Studies

There will be a requirement to carry out intensive propagation studies to demonstrate the required level of coverage is provided from the OHLE mounted radiating equipment.

As the environment generated by the OLE masts and pylons etc. creates an unfriendly path for RF causing possible reflections, multi path etc. leading to fast fading issues, it is essential to model the various scenarios for the differing technologies and frequencies used. It is generally considered that up to around 6GHz it is possible to cover the rail infrastructure without too many reflections etc. Above this frequency as the wavelengths become shorter the worst the reflections etc. become and special modelling and propagation studies need to be carried out to ensure good RF coverage and subsequently data speeds can be achieved.

It is outside the remit of this guidance note to offer any advice or guidance on this subject.

## 9.4 Backhaul Network

Whilst it is acknowledged that most systems that may be employed, to provide either connectivity to trains for customer broadband use, or indeed for both that and operational uses, to include signalling, train communications and data exchange into the future, there will be a need for backhaul connectivity, utilising one or a mix of the following potential options:

- NRT (FTNx)
  - Subject to agreement with Network Rail it may be possible to interconnect into their fibre network for backhaul use but establishing the requisite Points of Presence (PoP's) may be problematical.
- Private (New Fibre systems)
  - The use of supplier owned fibre may be a preferred option to using NR's system as it gives the operator more freedom in location of access to the fibre and possible other

commercial usage of this infrastructure but will still need containment and protection and would be subject to Network Rail consents if run on NR land.

- Mix (FTNX / New Private fibre)
  - Another option would be to use a mix of both networks if capacity was available from NR and a shared usage may be possible, again subject to mutual agreement between NR and the operator.
- Wireless Mesh/Optical Fibre
  - This technology removes the need for much of the backhaul along the Infrastructure but will still require connectivity to the Cloud or ISP for internet connectivity

It is outside the remit of this guidance note to offer any further advice or guidance on this subject.

# 10 Part H – Areas Outside Scope Which Require Further Consideration

This document is concerned with the feasibility of physically attaching radiating antenna onto existing OHLE support structures on Network Rail infrastructure.

A number of areas relate to future technological solutions and applications and are therefore out of scope. These areas shall require further consideration in due course as potential solutions and applications are developed.

## 10.1 Design of Appropriate Bracketry to Mount Antenna(s)

The proposed technological solution will drive the selection of appropriate antenna types/size/weight which will in turn influence the design of appropriate bracketry to mount this equipment.

The type of OLE structure will also influence the design of appropriate bracketry.

## 10.2 Equipment Design (Concept, Reference, Detailed)

The proposed technological solution will drive the design development of potential solutions.

## 10.3 Spectrum and Connectivity

The selection of spectrum and the wider connectivity of OLE mounted antenna to a backhaul network will be driven by the technological solution taken forward. Whilst general guidance is given in Part G of this document, further consideration of these areas will be required as a technological solution is developed.

## 10.4 Electrical Considerations

The impact on cable routes and quantum/type/routing of cables, provision of power supplies and effect of EMC again are driven by the technological solution taken forward. Whilst general guidance is given in Part D of this document, further consideration of these areas will be required as a technological solution is developed.

## 10.5 OHLE structures/solutions within tunnels

This subject requires further work to identify the special requirements for radio propagation, and clearances both from an electrical and gauging perspective and therefore is currently outside the scope of this document but could form the basis for future research into this subject.

## 10.6 Consideration of the applicability to HS1 and HS2

There are some specific challenges to be encountered on HS1 for mounting additional equipment on the OLE structures along the route.

Also as HS2 is still in development and the final design of the OLE infrastructure has not been finalised.

# 11 Conclusions

Mott MacDonald was commissioned by the Department for Transport (DfT) to explore the feasibility of utilising Overhead Line Equipment (OLE) structures to mount small cells and/or wireless antennas.

In terms of the feasibility of mounting small cell / wireless connectivity equipment onto OLE structures, the following areas were considered:

- Physical Mounting.
- Electrical Power, Earthing & Bonding, EMC.
- Product Approvals.
- Design Assurance.
- Installation.
- Maintenance.
- Spectrum & Connectivity.

Following industry-wide stakeholder consultation and engagement, it was established that it is feasible to utilise the majority of OLE structures to mount small cells and/or wireless antennas, subject to compliance with applicable legislation and standards.

Key requirements have been identified associated with the safe location, design, installation and maintenance of any equipment to be mounted on OLE structures. The rationale for each set of requirements is provided, followed by relevant guidance.

A number of considerations have been identified that are dependent upon the chosen antenna/technological solution and sit outside the scope of this commission, namely:

- Spectrum.
- Equipment design (Concept, Reference, Detailed).
- Electrical considerations – impact on cable routes and quantum/type/routing of cables, provision of power supplies, earthing and bonding and effect of EMC
- Provision of lineside connectivity including backhaul.
- Associated safety case/product approvals.
- Planning and Consents.
- OHLE structures/solutions within tunnels.
- Applicability to HS1 and HS2.

Whilst general requirements and guidance is provided in these areas, further consideration will be required in due course as potential solutions and applications are developed.

As well as understanding the requirements to be met to facilitate the safe design, installation and maintenance of potential OLE structure-mounted equipment, there is also a need for interested parties to understand the availability of OLE on a given route, including the type of OLE system and the quantum and range of OLE structure types present. This information is held by the asset owner, Network Rail, and will be needed to inform any decision on whether to use existing OLE structures or pursue an alternative approach.

# Appendices

# A. Applicable Standards

### Summary Tables of Standards

The following tables give a summary of the standards, guidance notes, Work Instructions and regulations that have been referred to and referenced in the Guidance Note.

This is not an exhaustive list, and these documents can be obtained via RSSB website, via British Standards shops and from various search engines via the web either for overview or purchase.

#### Legislation

| Number | Name | Overview |
|---|---|---|
| N/A | The Electricity at Work Regulations 1989. | Set out regulations and gives technical and legal guidance on them. |
| N/A | Health and Safety at Work etc Act 1974. | Lays down the duties on employers to protect the health, safety and welfare of all employers, others on their premise including visitors and the general public. |
| N/A | Management of Health and Safety at Work Regulations 1999. | Regulations made under HSWA and include Risk Assessments. |
| N/A | The Construction (Design and Management) Regulations 2015 | CDM aims to improve health and safety to plan work and manage risk from the outset. |
| N/A | The Work at Height Regulations 2005 | The Working at Height Regulations 2005 (WAHR) have no minimum height requirement for work at height. They include all work activities where there is a need to control a risk of falling a distance liable to cause personal injury. This is regardless of the work equipment being used, the duration the person is at a height, or the height at which the work is performed. It includes access to and egress from a place of work. |

**BS EN Standards & Recommendations**

| Number | Name | Overview |
|---|---|---|
| BS EN 50122-1:2011+A1:2011 | Actions on Structures. | Specifies requirements for the protective provisions relating to electrical safety in fixed installations associated with AC traction systems and to any installations that can be endangered by the traction power supply system. |
| BS EN 1990 Eurocode 0 | Basis of structural design (and associated national annex). | EN 1990 establishes Principles and Requirements for the safety, serviceability and durability of structures, describes the basis for their design and verification and gives guidelines for related aspects of structural reliability. |
| BS EN 1991 Eurocode 1 | Actions on structures (and associated national annex). | EN 1991 Eurocode 1 provides comprehensive information on all actions that should normally be considered in the design of buildings and other civil engineering works, including some geotechnical aspects. |
| EN 61537 | Cable Management - Cable Tray Systems and Cable Ladder Systems. | Type testing, Corrosion resistance, Electrical equipment, Communication cables, Electric cables, Electrical properties and phenomena, Communication systems (buildings), Classification systems, Mechanical properties of materials, Cable clips, Inspection, Electric cable systems. |
| IEC 61386 | Conduits systems for cable management. | This part of IEC 61386 specifies requirements and tests for conduit systems, including conduits and conduit fittings, for the protection and management of insulated conductors and/or cables in electrical installations or in communication systems up to 1000V AC and/or 1 500V DC. |
| BS EN 60825-2:2000 Superseded by BS EN 60825-2:2004 also known as IEC 60825-2:2004 | Safety of laser products: safety of optical fibre communications systems. | Gives requirements and specific guidance for the safe operation and maintenance of optical fibre communication systems (OFCS). |
| EN 50124-1 | Railway Applications - Insulation Coordination - Part 1: Basic Requirements - Clearances And Creepage Distances For All Electrical And Electronic Equipment. | Leakage paths, Railway vehicles, Railway equipment, Electrical engineering, Electrical insulation, Signals, Electronic equipment and components, Clearance distances, Electrical equipment Railway applications. |
| EN 50125-3 | Railway Application - Environmental Conditions | This Standard specifies the environmental conditions encountered within Europe. It can |

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| | For Equipment - Part 3: Equipment For Signalling And Telecommunications. | also be applied elsewhere by agreement between the supplier and the customer.<br>The scope of this European Standard covers the design and the use of equipment and any portable equipment for signalling and telecommunications systems (including test, measure, monitoring equipment, etc. |
| EN 50173 | Information technology – Generic cabling systems. | The structure and configuration of the backbone cabling subsystems of generic cabling systems within the types of premises defined by the EN 50173 series of standards. |
| EN 60950-1 | Information Technology Equipment - Safety - Part 1: General Requirements. | This standard is applicable to mains-powered or battery-powered information technology equipment, including electrical business equipment and associated equipment, with a RATED VOLTAGE not exceeding 600 V. This standard is also applicable to such information technology equipment: designed for use as telecommunication terminal equipment and TELECOMMUNICATION NETWORK infrastructure equipment, regardless of the source of power. |
| EN 60950-21 | Information Technology Equipment - Safety - Remote Power Feeding. | This standard applies to information technology equipment intended to supply and receive operating power via a telecommunication network, where the voltage exceeds the limits for TNV CIRCUITS. This Part 21 of IEC 60950 is intended to be used with IEC 60950-1. |
| EN 60950-22 | Information Technology Equipment - Safety - Part 22: Equipment Installed Outdoors. | This part of IEC 60950 applies to information technology equipment intended to be installed in an OUTDOOR LOCATION. |
| EN 60966-1 | Information Technology Equipment - Safety - Part 1: General Requirements Radio Frequency and Coaxial Cable Assemblies - Part 1: Generic Specification - General Requirements And Test Methods. | This part of IEC 60966 specifies requirements for radio frequency coaxial cable assemblies operating in the transverse electromagnetic mode (TEM) and establishes general requirements for testing the electrical, mechanical and environmental properties of radio frequency coaxial cable assemblies composed of cables and connectors. Additional requirements relating to specific families of cable assemblies are given in the relevant sectional specifications. |
| EN 61643-21 | Low Voltage Surge Protective Devices - Part 21: | Performance Requirements and Testing Methods. |

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|---|---|---|
| | Surge Protective Devices Connected To Telecommunications And Signalling Networks. | |
| EN 61663-1 | Lightning Protection - Telecommunication Lines - Part 1 - Fibre Optic Installations. | |
| IEC 62305 | Protection Against Lightning. | |
| IEC 60794-3-10 | Optical fibre cables – Outdoor cables. | Family specification for duct, directly buried and lashed aerial optical. |
| IEEE 1100 | Recommended Practice for Powering and Grounding Electronic Equipment - IEEE Emerald Book (Colour Book Series). | |
| BS EN 50121:2006, Parts 1 – 5 | Railway Applications – Electromagnetic Compatibility. Parts 1 – 5. | The set of standards provides both a framework for managing the EMC for railway systems and also specifies the limits for the electromagnetic (EM) emission of the railway system as a whole to the outside world and for the EM emission and immunity for equipment operating within the railway system. The latter is intended to be compatible with the emission limits set for the railway system as a whole and also provides for establishing confidence in equipment being Fit For Purpose in the Railway environment. |

**Railway Group Standards and RSSB Guidance Notes**

| Number | Name | Overview |
|---|---|---|
| Railway Group Standard GL/RT1210 | AC Energy Subsystem and Interfaces to Rolling Stock Subsystem. | Consolidates existing standards and practices for 25kV AC electrification, and mandates requirements in line with EU requirements for interoperability and migration towards a uniform system for 25kV AC electrified railway on Network Rail controlled infrastructure. |
| GE/RT8073 | Requirements for the Application of Standard Vehicle Gauges. | Defines standard vehicle gauges and the associated application rules for rolling stock and for infrastructure. |
| GE/RT8273 | Assessment of Compatibility of Rolling Stock and Infrastructure - Gauging and Stepping Distances. | This document mandates specific requirements and responsibilities for the assessment of gauging compatibility and stepping distances between rolling stock and infrastructure. |
| GI/RT7073 | Requirements for the Position of Infrastructure and for Defining and Maintaining Clearances. | Mandates requirements for positioning infrastructure and maintaining the position of track relative to infrastructure to achieve gauge compatibility with rolling stock. |
| GM/RT2173 | Requirements for the Size of Vehicles and Position of Equipment. | Mandates the methods of determining the swept envelope of rail vehicles. It mandates specific gauge requirements for the lower sector and specific items of equipment, and mandates minimum requirements for the recording of vehicle gauging data. |
| RIS-8270-RST | Route Level Assessment of Technical Compatibility between Vehicles and Infrastructure. | Sets out requirements and responsibilities for the assessment of technical compatibility at route level for vehicles and infrastructure. |
| RSSB GE/GN8573 | Guidance on Gauging and Platform Stepping Distances. | Guidance only. |
| GE/RT8000 | (The Rule Book) and all associated Modules and Handbooks. | The Rule Book (GE/RT8000) and other National Operations Publications are documents that contain direct instructions for railway staff. |
| RIS-0737-CCS | Signal sighting assessment requirements. | This document sets out the signal sighting assessment process that is used to confirm compatibility of lineside signalling system assets with train operations (signal sighting). |

| Number | Name | Overview |
|---|---|---|
| GL/RT1210 | Railway Group Standard: AC Energy Subsystem and Interfaces to Rolling Stock Subsystem. | This document defines the requirements for the AC energy system and the interfaces to rolling stock operating over the AC electrified railway. |

**Network Rail Standards, Guidance Notes & Work Instructions**

| Number | Name | Overview |
|---|---|---|
| NR/L2/CIV/073 | Design of Overhead Line Structures. | Provides overall requirements regarding basis of design, use of structural Eurocodes, the limit state philosophy, actions to be applied, partial factors and load combinations. |
| NR/L2/CIV/072 | Wind Loading of Overhead Line Equipment and Structures. | This standard defines the requirements for wind and ice loads for the design of overhead line equipment, structures, and foundations |
| NR/L3/ELP/27237/OLE/B01 | Overhead Line Work Instructions. | |
| NR/OLE B01 | Non-intrusive ground level visual inspections. | |
| NR/L3/ELP/27237/OLE/B01 | Visual inspection of OLE structures. | |
| NR/OLE B13 OLE | Asset condition assessment. | |
| NR/L2/CIV/003/F1990 | Technical Design Requirements for BS EN 1990. | |
| NR/L2/CIV/003/F1991 | Technical Design Requirements for BS EN 1991. | |
| NR/L2/INI/P3M/101 | Governance for Railway Investment Projects (GRIP) – Projects. | This Network Rail standard specifies the GRIP for projects lifecycle, its stages, stage gate reviews and the six-core level 3 standards required to manage a project throughout the lifecycle. |
| NR/L2/INI/02009 | Engineering Management for Projects. | This standard applies to all projects and the organisations working on projects that change, renew, enhance or remove Network Rail infrastructure assets. It applies to all phases of a project as applicable under GRIP. All types of project are applicable including, but not limited to:<br>a) feasibility studies;<br>b) design;<br>c) construction;<br>d) testing and commissioning;<br>e) maintenance;<br>f) asset protection; |

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|---|---|---|
| | | g) asset recovery;<br>h) de-commissioning and demolition;<br>i) projects which protect Network Rail's asset when a party other than Network Rail carries out work on, over or under Network Rail property;<br>j) projects carried out by an Alliance between Network Rail and another party / other parties (refer to Clause 5 for further information);<br>k) temporary works; and<br>l) emergency works (once the immediate requirements to make the railway safe have been met. |
| NR/L2/TEL/30022 | Engineering Assurance Arrangements for Communications Engineering Schemes and services. | To define procedures for the technical acceptance requirements for changes to the infrastructure to telecommunications schemes and services. |
| NR/L2/ELP/27311 | Engineering Assurance Requirements for Design and Implementation of Electrical Power. | The purpose of this specification is to control the risk to Network Rail's infrastructure and railway operations that may arise as a result of any changes to electrical power assets by mandating an engineering assurance process.<br>The standard provides details of the process for each phase of a scheme. |
| NR/L3/ELP/27406 | Engineering Deliverables for Electrical Power Asset Design. | The purpose of this specification is to provide the requirements for the Engineering Deliverables required to support the stages of assurance defined in NR/L2/ELP/27311. |
| NR/L2/INI/CP0070 | Principal Contractor Licensing Scheme. | The implementation of this standard enables Network Rail to:<br>a) verify that organisations/internal duty holders have the capability to discharge Principal Contractor (PC) duties when undertaking construction work where Network Rail is the client; and<br>b) provide ongoing assurance that the organisations/internal duty holders capabilities are maintained or improved. |
| N/A | Network Rail Health and Safety Management System (HSMS). | |
| NR/L3/ELP/29987 | Working on or About 25 kV AC Electrified Lines. | This modular standard sets out a consistent approach to working on or about 25 kV electrified lines in relation to the dangers arising from |

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| | | proximity to live equipment. This overarching standard for the modules provides an introduction to the suite of modules and consistent use of terminology in the application of the standard.<br><br>This standard and each of its modules should be read in conjunction with all other standards relevant to the activity to be undertaken.<br><br>NOTE: Further requirements are contained in the Rule Book Module AC (GE/RT8000/AC) and Handbook 16 (GE/RT8000/HB16). |
| NR/L2/OHS/019 | Safety of people at work on or near the line. | The purpose of this document is to provide guidance on how the requirements of 'NR/L2/OHS/019 – Safety of people at work on or near the line' should be delivered within Network Rail Route Businesses. This document is complementary to 'NR/L2/OHS/019 – Safety of people at work on or near the line' standard and can be used in conjunction with existing rule books, regulations, legislation, standards, processes and procedures. |
| NR/L2/OHS/133 | Code of Practice for Planning and Delivering Safe Work. | Network Rail PPP on planning safe work. |
| NR/L2/OHS/0044 | Planning and managing construction work | This standard applies to all construction work undertaken by or on behalf of Network Rail and covers any asset owned, managed, or occupied by Network Rail. |
| NR/L3/OPS/303 | Possession of the Line for Engineering Work Delivery Requirements. | This work instruction applies to all Network Rail staff and applicable support services contractors that plan work engineering access and deliver requirements associated with taking a possession of the line for engineering work upon Network Rail's managed infrastructure. |
| NR/GN/TEL/30139 | The Survey and Design of Telecoms Cable and Route. | This document provides guidance to the design and surveying of telecom cables and telecoms cable route. |
| NR/GN/TEL/30140 | Telecoms Cable Route Installation. | This document provides guidance to the installation of telecoms cables and telecoms cable route. |
| NR/L2/SIG/10157 | Signal Sighting Assessment Process. | This business process describes the process to assess signal sighting of proposed or applied signalling assets to be read and understood by train drivers and staff influencing train movements. |

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| | | The output of the assessment is a record of the considerations and judgements taken to define the recommendations of reasonable actions to optimise the interface between infrastructure and train driver. The record of assessment enables management of the risks associated with train operations controlled by new and existing signal assets. |
| NR/L2/SIG/10158 | Specification for signal sighting assessment. | This specification details the requirements to be applied when assessing signal sighting of proposed or applied signalling assets to be read and understood by train drivers and staff influencing train movements.<br>This specification gives clarity on, and additions to the requirements set out in RIS- 0737-CCS for undertaking signal sighting assessments.<br>This specification supports the signal sighting committee when undertaking signal sighting assessments. The record of assessment enables management of the risks associated with train operations controlled by new and existing signal assets. |
| NR/GN/ELP/27315 | Management of Power Supplies to Telecoms Equipment. | This document describes the electrification traction power systems forming part of the Network Rail's railway infrastructure. |
| NR/SP/TEL/30025 | Standby Power Supply Requirements for Operational Telecoms Equipment. | This standard sets out requirements for the provision of a standby power supply to enable Network Rail owned telecommunications equipment to continue to operate for a given period after the loss of the normal or primary power supply source. The standard introduces a complete and holistic approach to mandating the requirements around resilience, redundancy and backup power to Network Rail's telecommunication systems and assets. |
| NR/L2/ELP/27311 | Engineering Assurance Requirements for Design and Implementation of Electrical Power Engineering Infrastructure Projects. | The purpose of this specification is to control the risk to Network Rail's infrastructure and railway operations that may arise as a result of any changes to electrical power assets by mandating an engineering assurance process.<br>The standard provides details of the process for each phase of a scheme. |
| NR/L2/RSE/30041 | Electromagnetic compatibility (EMC) assurance process. | This standard specifies how Network Rail manages the risks of asset failure associated with known uncontrolled electromagnetic phenomena. |

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| | | It supports the Network Rail policy requirements as specified in NR/L1/RSE/30040 Electromagnetic Compatibility (EMC) Strategy for Network Rail, and its legal obligations under the EMC Regulations (2006). |
| NR/L1/RSE/30040 | EMC Strategy for Network Rail. | This standard specifies how Network Rail manages the risks of asset failure associated with known uncontrolled electromagnetic phenomena.<br>It supports the Network Rail policy requirements as specified in NR/L1/RSE/30040, Electromagnetic Compatibility (EMC) Strategy for Network Rail, and its legal obligations under the EMC Regulations (2006). |
| NR/L2//TEL/30003 | Immunity Test Requirements for Lineside Communications Systems. | This standard defines the test limits and test methods for induced voltages on copper telecommunications cables due to AC electrification systems in normal and credible failure modes.<br>This standard is intended to address the following risks that induced voltages on lineside copper may cause:<br>• hazardous accessible and touch voltages<br>• damage to systems connected to copper telecommunications cables<br>• interference to systems connected to copper telecommunications cables. |
| NR/L2/TEL/31106 | Overview of Electromagnetic Coupling Between Traction Systems and telecommunications Cables. | |
| NR/L2/TEL/31107 | Limits and Test Methods of Induced Voltages on Telecommunications Cables due to Electrification Systems. | This standard defines the test limits and test methods for induced voltages on copper telecommunications cables due to AC electrification systems in normal and credible failure modes.<br>This standard is intended to address the following risks that induced voltages on lineside copper may cause:<br>• hazardous accessible and touch voltages<br>• damage to systems connected to copper telecommunications cables |

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| | | • interference to systems connected to copper telecommunications cables |
| NR/SP/TEL/50016 | Methodology for the Demonstration of Compatibility with Telecommunications Systems. | This document provides a methodology to ensure electromagnetic compatibility with operational telecommunications equipment and systems adjacent to the AC and DC electrified railway on Network Rail controlled infrastructure. This is achieved by:<br>a) identifying generic types of safety-related, operational telecommunications equipment and systems present on Network Rail controlled infrastructure<br>b) determining maximum tolerable levels of interference at the terminal equipment<br>c) defining limits of interference at the terminal equipment due to rolling stock; and<br>d) compatibility argument.<br>This methodology will facilitate the demonstration of compatibility of rolling stock with operational telecommunications equipment and systems, as part of a Route Acceptance Safety Case. |
| NR/L3/ELP/27406/MOD L | Engineering Deliverable Requirements for Electrical Power Design – Module L AC/DC Traction Power Supply Interfaces. | The purpose of this specification is to provide the requirements for the Engineering Deliverables required to support the stages of assurance defined in NR/L2/ELP/27311. |