



LRSSB - LRG - 3.0

Management of Electromagnetic Compatibility (EMC) Guidance



**MANAGEMENT OF ELECTROMAGNETIC
COMPATIBILITY (EMC) GUIDANCE**

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LRG 1.1: Tramway Safety Principles and Guidance (LRSSB) (TPG) LRG 15.0: Stray Current Management (LRSSB) BS EN 50121: Railway applications. Electromagnetic compatibility See also other related documents and standards listed in Section 10					
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MANAGEMENT OF ELECTROMAGNETIC COMPATIBILITY (EMC) GUIDANCE

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Revisions from first issue:

Additional terms and abbreviations added to the Terms and Abbreviations table (from existing text).

Introductory text / section added at the front of the document to make consistent with other LRSSB 'LRG' guidance documents.

Paragraph numbering and section renumbering / document formatting in line with above additional text added and to be consistent with other LRSSB 'LRG' guidance documents.

Text added to aid clarification where required / appropriate.

Numerous presentational, minor factual and typographical changes.

TERMS AND ABBREVIATIONS

Table 1 – Terms

Term	Definition
Asset Family	EMC relevant equipment provided for a tramway /Light Rail scheme
Common Safety Method on Risk Evaluation and Assessment Process	ORR Guidance on the application of Commission Regulation (EU) 402/2013
Competent Person	Person appointed to oversee the safety assurance (or safety verification) process
Conducted Electromagnetic Stimulus	Electromagnetism caused by the physical contact of conductors
Electo-Motive Force	The electrical action produced by a non-electrical source
EM Field	A magnetic field produced by moving electrically charged objects
Fixed Installation	The tramway or Light Railway infrastructure
HAZID	Hazard Identification Process
Infrastructure Manager	Person who is responsible for developing and maintaining that infrastructure or manages and uses that infrastructure or station, or permits it to be used, for the operation of a vehicle
Radiated Electromagnetic Stimulus	Electromagnetism caused by induction
Relevant Safety Authority	For Network Rail – RSSB, for other equipment – OFCOM or the relevant Secretary of State
Scheme Sponsor	Promotor of a scheme
Scheme Sponsors EMC Manager	Manager appointed by the Scheme Sponsor
Statutory Undertakers	Certain bodies that have been given statutory powers in relation to roles that are of a public character, such as Utility Companies
Stray Current	A flow of electricity from the tramway which does not return via the rail but leaks into local Earth and buried conductors due to voltage imbalances
Transport and Works Act Order (or Transport and Works (Scottish) Act Order (TWA)	Statutory process for attaining Powers to build operate and maintain a tramway or Light Rail system
UKTram	Industry Body for Light Rail and Tramways

Table 2 – Abbreviations

Abbreviation	Definition
AC	Alternating Current
BS EN	British (BS) adoption of a European (EN) standard
CE	Conformité Européenne (European Conformity)
CfS	Case for Safety
COTS	Commercial Off The Shelf
Abbreviation	Definition
DC	Direct Current
EM Field	Electromagnetic Field
EMC	Electromagnetic Compatibility
EMF	Electro-Motive Force
EMI	Electromagnetic Interference
EU	European Union
FI	Fixed Installation
HMRI	Her Majesty’s Railway Inspectorate
ICNIRP	The International Commission on Non-Ionizing Radiation Protection
MUP	Mass Utility Provider
NR	Network Rail
O&M	Operation & Maintenance
ORR	Office of Rail and Road
RFI	Radio Frequency Interference
ROGS	Railways and Other Guided Systems 2006
RSA	Relevant Safety Authority
SFAIRP	So Far As Is Reasonably Practicable
SI	Statutory Instrument
SSS	Scheme Sponsors Specification
TD	Technical Documentation
SU	Statutory Undertakers
UK	United Kingdom

1. Introduction

- 1.1 This guidance supports the high level principles set out in LRG 1.1 Tramway Principles and Guidance (TPG) published by the Light Rail Safety Standards Board (LRSSB).
- 1.2 This document provides high level guidance for the Management of Electromagnetic Compatibility (EMC) for those delegated this responsibility in relation to UK Tramways and Light Rail systems based on 'line-of-sight' operations only. As with all guidance, this document is not prescriptive and is intended to give advice not to set a mandatory industry standard, and it is based upon goal setting principles as best practice. Much of this guidance is based on the experience gained from existing UK Tramways and Light Rail systems and from published documents.

2. Scope

- 2.1 The demonstration of EMC is a self-certification process. The demonstration of EMC in accordance with UK legislation in order to achieve necessary agreements and sign off by the relevant authority is not a clear and easily understood process. As a result, this can cause Scheme Sponsors (Promoters) to incur significant unnecessary costs.
- 2.2 Experience in the UK has been that the level of proof required for some Statutory Undertakers (SU) has been excessive and in particular, agreements with Network Rail (NR) have been complex and time consuming.
- 2.3 NR is in the process of modernising and upgrading its signalling systems. As this is a long term process, there still is a large amount of older legacy equipment on the heavy rail network that may not be sufficiently well protected from radiated or conducted electromagnetic stimulus (including stray DC currents). However, if new tramway / Light Rail systems are built to Standards and industry best practice, they should not present Electromagnetic Interference (EMI) to adjacent new or legacy infrastructure and in turn should have suitable levels of immunity from external EMC from other parties.
- 2.4 All rail infrastructure managers including NR have a duty of care under Railways and Other Guided Systems Regulations 2006 (ROGS) to protect their own infrastructure by seeking appropriate assurance from third parties that the safety of their system is not impaired. This can be achieved either by Safety Verification or the Common Safety Method on Risk Evaluation and Assessment process¹. Clause 22 of ROGS requires all parties to cooperate to achieve this.
- 2.5 Due to NR's concerns over the protection of their equipment (as above), they will as a matter of course object to any Transport and Works (TWA) Order application (England and Wales), or a Transport and Works (Scottish) Act Order application (Scotland) despite protections already being included in the drafting of any such Order.
- 2.6 The intention of this guidance document is to suggest a clear and staged approach to provide and demonstrate compliance with the Regulations, and to enable the Relevant Safety Authority (RSA) to provide a letter of 'Note and Support'.
- 2.7 This document does not supply all of the information needed to achieve self-certification, but suggests a method of delivering the process to demonstrate that adjacent electrical / electronic infrastructure will not be impacted by unwanted interference. This includes setting out a model for effective cooperation and communication between the promoter of the scheme and affected parties.

¹ <https://www.orr.gov.uk/sites/default/files/om/common-safety-method-guidance.pdf>

2.8 The EMC processes in this guidance document are applicable for:

- New schemes (including new infrastructure and vehicles),
- New infrastructure for an existing tramway / Light Rail system, and
- Introduction of a new fleet of vehicles on an existing tramway / Light Rail system.

2.9 For all Standards referenced in this document, the current versions should be used when implementing these guidelines unless otherwise clearly justified and documented.

3. The EMC Management Process

3.1 For tramways / Light Rail systems, the process of the management of EMC was historically through the creation of an EMC Management Plan, having undertaken all its requirements and measurements. Scheme Sponsors would then present this assurance to NR's Infrastructure Safety Review Panel (ISRP) who would then issue a 'Letter of No Objection' or letter 'Noting and Supporting' the assurance.

3.2 However, the management of EMC is now set out in UK law by The Electromagnetic Compatibility Regulations 2016 (SI 1091)² ('the Regulations'). These Regulations implement EU Directive 2014/30/EU³ that came into force on 20 April 2016; the UK withdrawal from EU will not affect the content or locus of the UK Regulations.

3.3 Since the implementation of the EU Directive and then the UK Regulations, NR is no longer authorised to issue such a letter. The EMC process for tramways / Light Rail systems is now underwritten by the RSA and for NR, the Rail Safety Standards Board (RSSB).

4. Scheme Permission

4.1 For any new tramway / Light Rail scheme, the Scheme Sponsor ('Promoter') will in most instances have applied for a TWA Order which provides Powers to build, operate and maintain a proposed route or scheme. This process requires consultation with affected parties including those with sensitive safety critical electrical equipment which may include NR, Airport Authorities, Port Authorities, Mass Utility Providers (MUP), Hospitals etc.


However, whether an application has been made for a TWA Order or not, it is the Scheme Sponsor's responsibility to ensure contact has been made with any adjacent stakeholder who they consider may be affected. They should advise third parties that a tramway / Light Rail system will be in the vicinity of their infrastructure operating an electrical / electronic system and radio frequency equipment on DC traction electrics and give them the opportunity to engage in the assurance process.

EMC Assurance Manager

4.2 The Scheme Sponsor is required to nominate a person responsible for delivering assurance that EMC is achieved - an EMC Assurance Manager. This person may enlist the assistance of an EMC expert to assist with the development and delivery of the required EMC documentation including the EMC Management Plan.

² <http://www.legislation.gov.uk/ukxi/2016/1091/contents>

³ Directive 2014/30/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to electromagnetic compatibility

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EMC Documentation

- 4.3 The EU EMC Directive requires that EMC documentation be produced for a Fixed Installation (FI). Under the UK EMC Regulations, the person who installs an FI must hold the EMC Documentation for the lifetime of the FI. For tramways / Light Rail systems this will be the Infrastructure Manger. The Infrastructure Manager must also ensure that the documentation can be made available to the relevant national authority on request during the lifetime of the FI.
- 4.4 A tramway / Light Rail system is classed as a 'Fixed Installation' in the Regulations, which state:
"Fixed installation" means a particular combination of several types of apparatus and, where applicable, other devices, which are assembled, installed and intended to be used permanently, at a predefined location."
- 4.5 The Scheme Sponsor will also require a copy of the EMC documentation. This will ensure that for any modifications or additions to the FI, a valid base of EMC documentation is available to amend in line with the FI modifications.

Modification & Decommissioning

- 4.6 Modifications and additions to the FI both during its operational life and its decommissioning must be appropriately documented to ensure that EMC is maintained, i.e. the EMC documentation reflects the EMC of the existing operational status of the tramway / Light Rail system.

5. Requirements Specification

- 5.1 For any tramway / Light Rail system, both the rolling stock and the infrastructure are areas of responsibility requiring a Scheme Sponsors Specification (SSS). This must meet all of the necessary Standards required to comply with the Regulations (see Section 9 below).
- 5.2 The SSS should require any supplier to ensure that any supplied Commercial Off the Shelf (COTS) equipment carries the CE Mark (where applicable) to demonstrate its compliance with the relevant required standards.
- 5.3 The CE marking of the component does not necessarily ensure that the resultant FI is compliant when the separate CE marked components have been assembled and are operated together as a system.

6. EMC Strategy

- 6.1 The Scheme Sponsor should document the SSS in an EMC Strategy as set out in Figure 6.1 below.


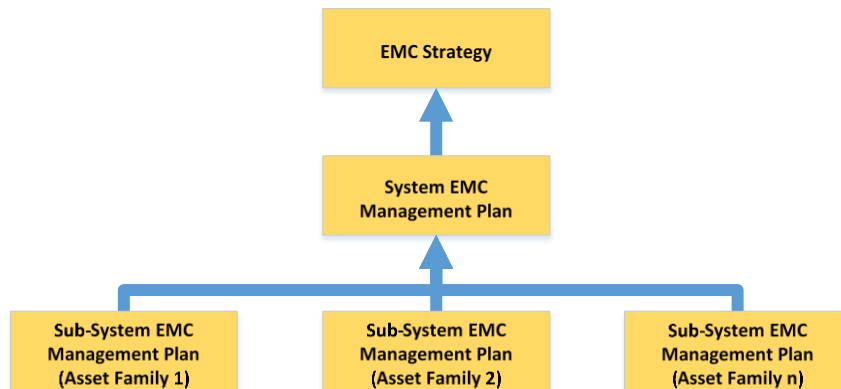
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Figure 6.1: EMC Strategy



6.2 This strategy is a hierarchical document that describes how the Scheme Sponsor intends EMC assurance to be delivered throughout the lifetime of the tramway / Light Rail system. It will need to demonstrate how it will not suffer from EMI and also not cause EMI to third parties.

6.3 The lifetime of the tramway / Light Rail system includes:

- Design;
- Construction;
- Testing and Commissioning;
- Operation and Maintenance, and
- De-commissioning.

6.4 For new tramway infrastructure the following effects are regarded as EMC issues (not exclusively):

- Radio Frequency Interference (RFI), transient and surge disturbances, RF emissions
- Harmonics and flicker;
- Crosstalk between parallel conductors (particularly inductive crosstalk);
- Rail touch voltage;
- Electromotive Force (EMF) - people safety in the presence of EM fields;
- DC stray currents (further guidance is given in LRSSB guidance document LRG 15.0 'Stray Current Management Guidance');
- Earthing and Bonding - relevant to rail touch voltage, galvanic separation and DC stray current.

6.5 Rail touch and step potentials are not strictly covered by the EMC Directive, but should be included for safety of persons.

6.6 The EMC Strategy should include:

- Introduction;
- System overview;
- EMC regulatory compliance;
- EMC environments;

- EMC standards: including relevant EN Standards and third party Standards where applicable (for example NR/SP/SIG/50004 'Methodology for the Demonstration of Electrical Compatibility with DC (AC Immune) Track Circuits');
- Special Cases (for example NR, MUP, etc.);
- Supplier EMC Deliverables:
 - EMC Management Plan;
 - EMC Hazard Analysis, and
 - EMC Certification Report.
- Scheme Sponsor Acceptance Criteria (the following 3 bullet points are offered as an example):
 - Code 1: Work may proceed: no changes to the submitted documentation required
 - Code 2: Work may proceed: revise and resubmit in line with the changes on the provided comment sheet;
 - Code 3: Work may not proceed: urgently revise and resubmit in line with the changes on the provided comment sheet. The issue raised may have significant cost implications to the scheme.


6.7 The final product of the EMC strategy should be EMC Technical Documentation for a new or revised tramway / Light Rail system. This documentation demonstrates the EMC of the tramway / Light Rail system.

6.8 This Technical Documentation should be held by the Infrastructure Manager for the lifetime of the tramway / Light Rail system and made available to the Competent Person overseeing the safety verification process who will report to the promoter's senior management / client, and may refer more serious issues to the Office of Rail and Road (ORR) if appropriate.

7. EMC Management Plan

7.1 All suppliers should document the SSS in an EMC Management Plan. This plan should cover all aspects of the proposed suppliers' asset family for the life of the tramway / Light Rail system including (not exclusively) the following:

- 1) Asset family overview: To include scope and brief description of EMC relevant equipment to be provided for the scheme. This should include a note of any special cabling requirements.
- 2) EMC management and organisation within the asset family.
- 3) Overview of EMC design and control methodologies: This will describe the planned EMC measures for the various subsystems and relevant standards for equipment. The need for a hazard identification (HAZID) study will be addressed here.
- 4) Management of EMC interfaces: This will address the strategy for dealing with:
 - intra-system EMC (EMC between the systems within the asset family),
 - intersystem EMC (EMC between the systems within the asset family and systems within other asset families i.e. vehicle to signalling), and
 - extra-system EMC (EMC between systems within the asset family and third party systems).
- 5) Deliverables Schedule: A list of further EMC documentation required for the asset family will be produced. This should include:
 - An EMC Hazard Analysis;
 - EMC Certification Report, and

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- EMC Test Plans for inadequately documented equipment and subsequent Test Reports for the equipment, etc.

7.2 The system EMC Management Plan and those for the sub-systems should identify the delegation of responsibility for the management of interface EMC issues and emergent system EMC issues so that it is clear who has the lead responsibility in resolving them.

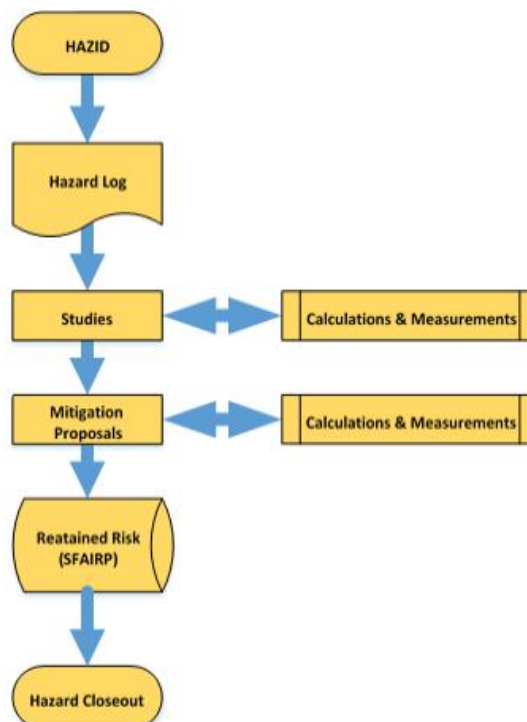
7.3 If EMC certification for a system is inadequate for its intended environment, a standards gap analysis should be performed. This will show the difference between existing EMC certification and what is required for the intended EMC environment on the scheme. Where gaps exist between the documented measurements and the required standards, equipment should be retested, modified or even replaced so that certification is appropriate.

7.4 Inadequately certified equipment should be listed in the EMC Hazard Log. The hazard would then be closed when appropriate certification is in place. The results of the gap analysis may act as a basis for further EMC Test Plans, testing and Test Reports in order to bridge any gap in standards.

8. Hazard Analysis

8.1 The process for dealing with hazards is shown in Figure 8.1 and then further detailed below.

Figure 8.1: Hazard Analysis



8.2 HAZID should be undertaken by a suitably qualified panel comprising of all the interested parties. They will identify all of the EMC hazards for consideration and allocate ownership to each one.

8.3 The hazards are then analysed to understand the likelihood and the severity of the identified risks.

- 8.4 Mitigation measures are then identified for each risk. These will be re-analysed with potential further mitigation measures until risks have been reduced So Far As Is Reasonably Practicable (SFAIRP) to a level that is acceptable and tolerable. This may require an analysis to demonstrate that further reduction of the risk would be grossly disproportionate in a benefit to cost argument.
- 8.5 The final part of the hazard management is to formally close the risk. The Hazard Log will then be monitored to ensure that acceptable risk levels do not change and are being adequately managed.
- 8.6 The Scheme Sponsor's EMC Manager owns the EMC Hazard Log and should ensure that all interface and control issues can be assured as being managed, and that all standards and legislation have been adhered to.

9. Testing

- 9.1 The EMC test standards described below give the prescribed levels of EM performance for electrical / electronic apparatus. In the absence of specific tramway / Light Rail group standards, the generally applicable (heavy) railway standards on EMC are applied.
- 9.2 For equipment, these tests should be performed on representative apparatus in the laboratory enabling the CE marking to be applied. In some cases, this marking has already been obtained for other railway applications and it is possible to assess these cases against the new environment.
- 9.3 The harmonised standards for EMC within tramway / Light Rail systems are the appropriate parts of BS EN 50121⁴ as summarised below:
- BS EN 50121-1: Railway applications. Electromagnetic compatibility. General;
 - BS EN 50121-2: Railway applications. Electromagnetic compatibility. Emission of the whole railway system to the outside world;
 - BS EN 50121-3-1: Railway applications. Electromagnetic compatibility. Rolling stock. Train and complete vehicle;
 - BS EN 50121-3-2: Railway applications. Electromagnetic compatibility. Rolling stock. Apparatus;
 - BS EN 50121-4: Railway applications. Electromagnetic compatibility. Emission and immunity of the signalling and telecommunications apparatus;
 - BS EN 50121-5: Railway applications. Electromagnetic compatibility. Emission and immunity of fixed power supply installations and apparatus.
- 9.4 These standards set out limits for emissions and immunity such that compliant apparatus should operate correctly when placed in the tramway / Light Rail environment.
- 9.5 A structured plan should be drawn up that progressively builds up from tests on components, if necessary, to sub-system then whole system operational tests. Stage gates should be built into the test plan to ensure successful completion of lower grade tests before progressing to more complex system tests. This should be agreed with affected parties who may need to undertake monitoring on their own systems as part of the testing.

⁴ BS EN 50121: Railway applications. Electromagnetic compatibility

9.6 Other Standards & Guidelines

- BS EN 50500: Measurement procedures of magnetic field levels generated by electronic and electrical apparatus in the railway environment with respect to human exposure;
- ICNIRP: Guidelines for limiting exposure to time-varying Electric, Magnetic, Electromagnetic fields (Up to 300 GHz);
- ICNIRP: Guidelines for limiting exposure to Static Magnetic Fields.

Other Relevant Reference Standards

9.7 Generic EMC Test Standards

- BS EN 61000-6-1: EMC Generic Standards - Immunity for residential, commercial and light industrial environments;
- BS EN 61000-6-2: EMC Generic Standards - Immunity for industrial environments
- BS EN 61000-6-3: EMC Generic Standards - Emission standard for residential, commercial and light industrial environments;
- BS EN 61000-6-4: EMC generic Standards - Emission standard for industrial environments;
- Other standards in the 6100 series (Electromagnetic Compatibility) may also be relevant in some cases.

9.8 Network Rail

- NR RT/E/C/50018: Methodology for the Determination of Interaction with Neighbouring Railways;
- NR/L1/RSE/30040: EMC Strategy for Network Rail;
- NR/L2/RSE/30041: EMC assurance process for Network Rail;
- NR/SP/ELP/27224: Installation of cable routes forming part of the traction distribution system;
- NR/SP/TEL/50016: Methodology for the Demonstration of Compatibility with Telecommunication systems.

9.9 Signalling and Telecommunications


- BS EN 41003: Particular safety requirements for equipment to be connected to telecommunication networks.

9.10 Rolling Stock

- BS EN 50238: Railway Applications - Compatibility between rolling stock and train detection systems;
- BS EN 50155: Railway Applications - electronic equipment used on rolling stock.

9.11 Mechanical and Electrical Services

- BS EN 55015: Limits and methods of measurement of radio disturbance of electrical lighting and similar equipment;
- BS EN 61547: Specification for equipment for general lighting purposes. EMC immunity requirements;
- BS EN 60439-1: 1999: Low voltage switchgear and control gear assemblies – Part 1: type – tested and partially type-tested assemblies.

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9.12 Power

- BS EN 50162: Protection against corrosion by stray current from direct current systems;
- BS EN 50163: Railway Applications - Supply Voltages to Traction Systems;
- BS EN 50160: Voltage characteristics of electricity supplied by public distribution systems;
- ENA Engineering Recommendation G5/4-1: Planning Levels for Harmonic Voltage Distortion and the Connection of Non-Linear Equipment to Transmission Systems and Distribution Networks in the United Kingdom.

9.13 Earthing, Bonding and Lightning Protection

- BS7430: Code of Practice for Earthing;
- BS EN 62305-1: Protection against Lightning. General Requirements (and other standards in the same series);
- BS EN50122-1: Railway Applications - Fixed Installations Part 1: Protective provisions relating to electrical safety and earthing;
- BS EN50122-2: Railway Applications - Fixed Installations Part 2: Protective provisions against the effects of stray currents caused by DC, traction systems;
- BS EN50310: Application of equipotential bonding and earthing at premises with information technology present.

9.14 Cabling

- BS7671: Requirements for Electrical Installations. IET Wiring Regulations;
- BS EN50174: Information Technology - Cabling Installation (Parts 1 - 3);
- BS EN61000-5-2: Electromagnetic compatibility. Installation and Mitigation guidelines. Earthing and cabling.

9.15 The levels of EMC compliance with the various standards described herein should be documented in the Operation and Maintenance (O&M) manuals.

9.16 Any outcomes of testing that require to have particular attention going forwards through maintenance should also be suitably documented in (O&M) manuals.

10. Technical Documentation

10.1 The Technical Documentation (TD) will comprise the documentation listed in Table 10.1 below.

Table 10.1: Technical Documentation

Asset Family	Document	From	To
Depot	EMC Management Plan	Supplier	Scheme Sponsor
	Hazard Analysis		
	Certification Report		
Control Room	EMC Management Plan		
	Hazard Analysis		
	Certification Report		
Electrification	EMC Management Plan		
	Hazard Analysis		
Signalling	EMC Management Plan		
	Hazard Analysis		
	Certification Report		
Sub-stations	EMC Management Plan		
	Hazard Analysis		
	Certification Report		
Track-side systems	EMC Management Plan		
	Hazard Analysis		
	Certification Report		
Trams	EMC Management Plan		
	Hazard Analysis		
	Certification Report		
Whole Railway	EMC Strategy		
	Letters of Note and Support	Special Case Third Party	
	EMC Test Plan(s)	EMC Specialist	
	EMC Test Report (pre-energisation)		
	EMC Test Report(s)		
	EMC Assurance Document		
	Document Package	Scheme Sponsor	Responsible Person and ORR

10.2 When the documentation is complete, the Scheme Sponsor should supply the Infrastructure Manager with the documentation as well as providing a copy to the Competent Person for their EMC safety verification assurance.

11. Acceptance by RSA


Schedule of Key Milestones and Tasks

11.1 Listed below are the stages towards EMC compliance and acceptance by the RSA. This is followed by Figure 11.1 that illustrates the interaction with the RSA as part of this process.

11.2 The Scheme Sponsor should agree formal timescales and deliverables with the RSA at an early stage to ensure an efficient and cost effective process.

11.3 Stage 1 - EMC Strategy

- Prepare the EMC strategy documentation (as detailed in Section of this document) detailing interaction with any relevant third parties;

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- Submit EMC Strategy to the RSA;
- Receive RSA response - 'Noting and Supporting'.

11.4 Stage 2 - HAZID.

- Perform the HAZID analysis (as detailed in Section 8 of this guidance);
- Carry out multi-discipline risk assessment;
- Prepare of EMC Case for Safety (CfS) for interface with third party infrastructure and equipment including NR;
- Submit the CfS to RSA;
- receive response from RSA - 'Noting and Supporting'.

11.5 Stage 3 - Immunisation Modelling

- Carry out EMC Studies:
 - Signalling;
 - Other (non-signalling) assets;
- Submit EMC Studies to RSA;
- Receive RSA response - 'Noting and Supporting'.

11.6 Stage 4 - Immunisation Works

- Design resultant agreed mitigation works of third party assets;
- Submit designs to RSA for approval;
- RSA approval;
- Implement alterations to third party assets;
- Test and verify altered assets;
- Submit report demonstrating successful testing to RSA;
- RSA accept altered assets.

11.7 Stage 5 - EMC Testing

- Prepare the EMC test plan (as detailed in Section 9 of this document);
- Submit EMC test plan to RSA;
- RSA Response 'Noting & Supporting'.

11.8 Stage 6 – Case for Safety

- Update Final CfS with Assurance of Compatibility;
- Submit Final CfS to RSA;
- Receive RSA Letter 'Noting and Supporting' bringing new rolling stock and / or Infrastructure into Passenger Service.

Figure 11.1: Interaction with the RSA for EMC compliance

