

TRANSPORT AND WORKS ACT 1992

TRANSPORT AND WORKS (INQUIRIES PROCEDURES) RULES 2004

NETWORK RAIL (CAMBRIDGE SOUTH INFRASTRUCTURE ENHANCEMENTS) ORDER

**MAIN PROOF OF EVIDENCE
ON MATTERS OF ELECTROMAGNETIC INTERFERENCE**

**JOHN MCAULEY ON BEHALF OF
THE UNIVERSITY OF CAMBRIDGE**

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1 INTRODUCTION

Name and qualifications

- 1.1 My name is John McAuley.
- 1.2 I am an Electrical and Electronic Engineer and have a Degree in Engineering, a Masters Degree in Electronics and am a member of the Institution of Engineers of Ireland (IEI). I am based at Compliance Engineering Ireland's offices in Co. Meath.
- 1.3 I am Chairman of the Irish National Committee on Electrotechnical Standardisation on electromagnetic compatibility ("**EMC**") and electromagnetic fields ("**EMF**") and human health, which provide the national position on these subjects. I attend committees of the European Standards Agency CENELEC TC210 on EMC and TC106X on EMF.
- 1.4 I am the Managing Director of Compliance Engineering Ireland Ltd. (CEI). CEI is an ISO accredited electrical test laboratory with laboratories in the Republic of Ireland and Northern Ireland and carries out EMC testing, radio and telecommunications equipment testing, electrical safety testing, Machinery Directive assessments and radiation hazards surveys. CEI is a member of the European Community Association of EMC Notified Bodies (EUANB) and the Radio Equipment Directive Compliance Association (REDCA).

Experience

- 1.5 I have specialised in the subjects of EMF and radiofrequency ("**RF**") engineering and have been a designer and consultant in these subjects for more than thirty years. I have managed a number of local and international projects involving the modelling of the coupling between railway systems, the local environment, trackside signalling and telecommunications, and the consideration of the effects of railway and other radio communication transmitters on co-located equipment.
- 1.6 I have carried out analysis of a number of overhead powerline lines as part of environmental impact assessment and related environmental statement preparation.
- 1.7 I have also supervised the EMC and electrical safety compliance testing of over one thousand electrical and electronic products. I have designed and installed a number of successful RF and power frequency magnetic field shielding systems.

- 1.8 I provide courses on the subjects of EMC, electromagnetic fields and human health, machinery assessments and electrostatics.

Scope of evidence

- 1.9 The scope of my evidence concerns the impacts of EMF from the construction and operation of the proposed Scheme.

2 SCOPE OF EVIDENCE

Scope of Evidence

- 2.1 My Proof of Evidence has been prepared in relation to the University of Cambridge's ("**University**") objection to the Network Rail (Cambridge South Infrastructure Enhancement) Order ("**Order**").
- 2.2 My evidence concerns the effects on the University's Anne McLaren Building ("**AMB**") from electromagnetic interference ("**EMI**") of the construction of the works and from the operation of the Scheme as set out in the draft Order ("**Scheme**"). I have been instructed by the University to consider, in particular, the effects on specialist equipment used in the AMB that is sensitive to EMI. The specialist equipment includes MRI, confocal microscopes and CT scanners.
- 2.3 The University also has an interest in the nearby area of land known as "Plot 9" and I briefly consider the potential effects of the Scheme on the development and use of Plot 9.
- 2.4 My evidence first considers the adequacy of the information which has been provided by Network Rail, in the documents accompanying the application, the information requested by the University and the response by Network Rail to those requests. Secondly it considers what is required in order to limit potential damage to the University's interests by way of controls either within Protective Provisions on the face of the Order and/or in a separate Land and Works Agreement.

The University's Concerns

- 2.5 The essence of the Scheme is to install two additional tracks (loops) and a new four platform station. The new loops are connected to the main line by way of newly installed switches and crossings. In the operating phase of the Scheme, EMI from the railway as received at the AMB would potentially increase by virtue of the increased

current drawn by the new trains, both passenger and freight, and the closer proximity of the nearest track.

2.6 The University is a statutory objector for the purposes of the Transport and Works (Inquiries Procedure) Rules 2004.

2.7 In relation to EMI, the following potential effects on the AMB need to be considered:

2.7.1 effects on sensitive equipment installed in the building; and

2.7.2 on research work dependent on the output from the equipment.

The University's Objection

2.8 Whilst the University supports improvements to public transport provision at Cambridge South, it maintains its objection to the Scheme because it is not satisfied that its effects on the University have been adequately assessed or mitigated and would therefore be harmful to its estate and interests. My evidence develops these concerns with specific reference to the effects of EMI, having regard to the information which has been provided by Network Rail. As I explain below, as matters stand that evidence is deficient and is incapable of assuring the University that its concerns can be overcome.

3 **THE NATURE OF EMI**

Introduction

- 3.1 This section summarises the topic of the measurement and assessment of EMI.
- 3.2 EMI impacts many electrical and electronic products. Research centres such as AMB use instruments that are particularly susceptible to EMI. These instruments use magnetic techniques as part of their process or use devices that are affected by EMI. The AMB uses a research MRI which has a defined environmental specification. In addition, the institute uses CT scanners and confocal microscopes. A full audit of the instruments in use has not been carried out.

Electromagnetic Fields and Units

- 3.3 The EMI levels to which I will refer in my evidence, are measured in units of volts/metre (V/m) for electric fields and microtesla (μT) for magnetic fields.
- 3.4 Electric trains generate several types of EMF. The traction system is fed from substations at frequent intervals along the rail producing AC (50Hz) electric and magnetic fields. The location of the substations determines the path of current flow to the trains and therefore the local magnetic field strengths. The electric fields are not of concern as they are absorbed by building materials. Conversely the magnetic fields pass readily through common building materials. The power source for the trains is a 25kV feeder system which is fed via an over head conductor and returned via the rails. The steel rails are bonded at frequent intervals using more conductive cables. The train generates a number of interference types including:

Source	Frequency	Interference Type
Traction System	AC	AC electric and magnetic fields at 50 Hz
Pantograph contact	Radiofrequency	Fast transients caused by arcing
Electronic systems	Radiofrequency	RF fields
Moving metal mass	Quasi DC	Magnetic fields DC to 2 Hz

4 LEGISLATION, POLICY AND GUIDANCE FOR EMI

Legislation

- 4.1 All products placed on the UK market have been subject the EU EMC Directive 2014/30/EU (UK Electromagnetic Compatibility Regulations 2016, S.I. 2016/1091, as amended in 2019) ("**Regulations**") which provide a basic level of protection for most products.
- 4.2 The Regulations refer to standards as a means to demonstrate compliance with the legislation which confers the "presumption of conformity". The following are the essential requirements:
 - 4.2.1 Equipment shall be so designed and manufactured, having regard to the state of the art, as to ensure that:
 - (i) the electromagnetic disturbance generated does not exceed the level above which radio and telecommunications equipment or other equipment cannot operate as intended; and
 - (ii) it has a level of immunity to the electromagnetic disturbance to be expected in its intended use which allows it to operate without unacceptable degradation of its intended use.

EMI Standards

- 4.3 The references to standards for electromagnetic compatibility in support of the Regulations provide a limited set of requirements that cover the most common interference types. In the respect of railways the relevant standard is "EN 50121-2:2006 Railway applications: Emission of the whole railway system to the outside world". This standard only specifies limits for radio frequencies above 9 kHz to protect radio and TV transmissions. As the range of equipment that is susceptible to emissions below 9 kHz is limited the standard does not specify limits.
- 4.4 The Regulations do not specify an upper or lower frequency.

5 METHODOLOGIES AND CALCULATION OF EMI

Introduction

- 5.1 The transmission of EMI from a railway into a building is mainly via the radiated path. Predictions of EMI start with the source characteristics. For trains this is dependent on the voltage that the train is supplied at (25kV in this case) the current drawn, the frequency of train passing events and the train speed.
- 5.2 The train is provided with power by the overhead lines with the return current via the rails and there may be feeder wires used. The EMFs from the 50Hz AC traction currents can be calculated (modelled) with a high degree of accuracy.
- 5.3 The Quasi static/DC magnetic disturbance as caused by the moving metal mass passing through the earths' magnetic field is difficult to model as the amount of steel used is not known. A significant part of the train above bogey level comprises non-magnetic materials such as aluminium which do not perturb the earths magnetic field.
- 5.4 There may be some limited mitigation of the EMI by building structures although for frequencies of interest this is usually negligible. Shielding of quasi DC and AC magnetic fields requires thick sections (up to 6mm) of high permeability or conductive materials such as mumetal or specialised steels.

Methodologies and criteria for assessing effects on the AMB

Overview

- 5.5 In the case of equipment that is sensitive to EMI, account has to be taken of the specific equipment already installed or for which installation is anticipated. The acceptability of a location for the satisfactory operation of EMI equipment therefore needs to be assessed on a case-by-case basis.
- 5.6 The sensitivity of equipment to quasi static and AC fields is largely known.
- 5.7 For equipment that has not previously been characterised or where the manufacturer has not set an environmental specification on-site testing can be carried out to determine the susceptibility levels.

6 RECEPTORS AND SOURCES AT THE AMB

Existing sources of EMI

- 6.1 The principal existing source of EMI at the AMB is the existing railway, together with the EMI from other services and equipment within the building.

Receptors in the AMB sensitive to EMI

- 6.2 There is one known equipment that is sensitive to EMI – the Bruker BioSpec®MR instrument. In addition, there are items of equipment that are known receptors including CT scanners and confocal microscopes.
- 6.3 I have been provided with EMI survey results contained within a wider report prepared by Ramboll that was itself prepared in 2014 in connection with the design of the AMB. In general, field levels were recorded at below general public health and technological requirements (albeit that this did not address the requirements of specific equipment within the AMB). The recommendation was that the survey results should be compared with any specific requirements of the use of the building. It was reported, for example, that magnetic field values found at the site could be incompatible with sensitive laboratory equipment, such as MRI scanners. Following installation of the relevant equipment within the AMB, I understand that initial operations did not indicate any concerns relating to the performance of that equipment (however further work is in my view required to be undertaken by Network Rail to understand EMI impacts on the AMB, as I explain below).

Future sources of EMI

- 6.4 Future sources will include those that are temporary (during construction and any advance works for the Scheme) and new permanent sources (from the operation of the Scheme once completed).

Construction Phase

- 6.5 Construction activities typically do not cause significant EMI. These would be negligible compared to the existing rail traffic contributions.

Operating Phase

- 6.6 The passage of trains is the principal source of EMI in the AMB. The highest levels are caused by higher speed trains and by a higher concentration of trains passing because of the two new tracks.
- 6.7 Network Rail have indicated that the proposed future distance from the nearest rail of the southbound loop to the edge of the AMB is 47.61m. This compares with the existing distance of 53.4m. The nearest of the through tracks will be moved 0.8m nearer to the AMB reducing the distance of 53.4m to 52.6m.

7 REVIEW OF ENVIRONMENTAL STATEMENT

Introduction

- 7.1 A site survey report has been provided in the Environmental Statement (“**ES**”). No date for the survey is indicated. In addition, there is no information of the type of trains passing. Information would be required on the type of trains, speed, current drawn, source of current supplied (location of substation).

Information not provided in the ENVIRONMENTAL STATEMENT

Operational phase - EMI

- 7.2 The assessment carried out and reported in the ES does not explicitly consider the types of receptor which exist in the AMB.
- 7.3 It is necessary to carry out a proper assessment of the potential for mitigation, including active cancellation of magnetic fields and architectural shielding.

Operational phase – Simultaneous train movements

- 7.4 In the case of sensitive equipment and other receptors in the AMB exceedance of EMI criteria by any combination of train movements is a potential significant effect. The following information is required as result:
- 7.4.1 Predictions of maximum quasi DC and AC fields due to all combinations of train operations should be provided and assessed.

8 CONCLUSIONS

- 8.1 My conclusion is that the Order application documents, including the ES and Statement of Case which have been submitted by Network Rail are inadequate for the purpose of considering the potential impacts of EMI on the operations within the AMB.
- 8.2 The University have requested further information, some of which has been received, and some of which is awaited. Any recent information received from Network Rail at the time of preparing my evidence is not covered in this Proof of Evidence and I will comment further, as necessary, in Rebuttal evidence.
- 8.3 Outstanding information includes a prediction of quasi static and AC magnetic field levels and their effects on the existing equipment in the AMB.
- 8.4 A detailed modelling exercise is required that is based on the new track configurations, substation locations and resultant current flows. The timetable for the new services and types of trains is required to determine the maximum current flows.
- 8.5 This information is necessary to ensure that the following key objectives can be achieved in relation to the EMI issue in this case:
 - 8.5.1 there must be measures which avoid any potential for increased EMI within the AMB (including interference to sensitive research equipment and AMB electrical services);
 - 8.5.2 there must be mitigation to avoid any exceedance of the environmental limits of sensitive research equipment within the AMB.
- 8.6 It will also be necessary to ensure that adequate surveys and modelling take place to ensure that these fundamental requirements are complied with.

9 WITNESS DECLARATION

9.1 I hereby declare as follows

9.1.1 This proof of evidence includes all facts which I regard as being relevant to the opinions that I have expressed and that the inquiry's attention has been drawn to any matter which would affect the validity of that opinion.

9.1.2 I believe the facts that I have stated in this proof of evidence are true and that the opinions expressed are correct.

9.1.3 I understand my duty to the inquiry to help it with matters within my expertise and have complied with that duty.

John McAuley

Compliance Engineering Ireland Ltd