

# **Cambridge South Infrastructure Enhancements**

Electromagnetic Compatibility Proof of Evidence

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## Acronyms and Abbreviations

Abbreviation	Description
AC	Alternating Current
ALARP	As Low As Reasonably Practicable
AMB	Anne McLaren Building
ASZ	Airport Safety Zone
BS	British Standard
CBC	Cambridge Biomedical Campus
CSIE	Cambridge South Infrastructure Enhancements
DRN	Document Review Notice
E&B	Earthing and Bonding
E&P	Electrical And Plant
EMC	Electro- Magnetic Compatibility
EMI	Electro Magnetic Interference
EN	European norm
ES	Environmental Statement
ETSI	European Telecommunications Standards Institute
FCI	Francis Crick Institute
GRIP	Governance for Railway Investment Projects
GSM+R	Global System for Mobile Communication (Railways)
HAZID	Hazard Identification
HV	High Voltage
IET	Institute of Engineering and Technology
kV	Kilo Volt
LMB	Laboratory of Molecular Biology
MRC	Medical Research Council
NR	Network Rail
OLE	Overhead Line Equipment

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Abbreviation	Description
R&TTE	Radio and Telecommunication Terminal Equipment
RFI	Radio Frequency Interference
TWAO	Transport and Works Act Order
UoC	University of Cambridge
WAML	West Anglia Main Line

*Table 1. Acronyms and Abbreviations*

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# 1 Introduction

- 1.1.1 My name is R. Rasheed Hameed. I am a Technical Director, Rail System Director within Arcadis and professional Head of Electrical And Plant (“**E&P**”) at Arcadis. I have been retained by Network Rail to provide specialist advice on Electromagnetic Compatibility (“**EMC**”) matters pertaining to the Cambridge South Infrastructure Enhancements (‘CSIE’) Project (“the **CSIE Project**”). I have over 30 years’ experience as a railway E&P and EMC specialist.
- 1.1.2 I am a chartered Engineer of the Institute of Engineering and Technology (IET).
- 1.1.3 As professional head of E&P department at Arcadis, I am in charge of organising a team of specialist designers and testers to deliver robust and cost-effective traction power, EMC, and Earthing & bonding technical solutions for railway projects in the UK and overseas.
- 1.1.4 My involvement on the CSIE Project began in 2018 when Arcadis was awarded the contract to deliver the environmental impact assessment to support the Transport and Works Act Order application (“the **TWAO application**”). My role on the project was to undertake technical review of all EMC and Earthing and Bonding (“**E&B**”) reports completed as part of this commission. In this regard, I have completed technical reviews of the EMC Strategy and EMC Control plan that have been delivered at the early stages of the project.
- 1.1.5 As a technical reviewer for the CSIE Project, I have a good understanding of the EMC work that has been carried out from the early stages of the project until today.
- 1.1.6 I will provide evidence on all EMC matters including:
- a. A summary of EMC work carried out to date, the identified potential impacts and effects of the CSIE Project on the EMC environment, including third-party stakeholders that could be impacted, the mitigations proposed, and any residual effects anticipated. These are summarised from the various EMC reports that have been produced as part of the TWAO application and are presented in section 5 of my evidence.
  - b. Responses to objections that refer to EMC. These are presented in section 6 of my evidence.
  - c. My conclusions as to the significance of the main residual effects on EMC and the implications for consenting CSIE are presented in section 7.
- 1.1.7 As part of my evidence, I will address the matter identified as **Issue 3(h)** within the Statement of Matters dated 27 October 2021.
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1.1.8 My evidence will be broken down into the following sections:

- Section 1: Introduction
- Section 2: Evidence Summary, contains a summary of this proof of evidence
- Section 3: CSIE Project Overview, contains a summary of key elements of the project
- Section 4: Relevant Legislation and Policy Context, summarises the relevant legislation and policy applicable to the EMC assessment carried out for CSIE
- Section 5: Presents a summary of work undertaken to date. The EMC assessment work, which was carried out as part of the CSIE Project, includes a desk-based assessment, documentation delivered and engagement with stakeholders. It summarises the EMC Significant Effects of CSIE to support the TWAO application. It also presents highlights of the work that is currently ongoing and that will be undertaken to address the key EMC issues that have been identified in this project.
- Section 6: Response to Objectors, contains response to the objectors who raised regarding Electromagnetic Interference (“**EMI**”) emission
- Section **Error! Reference source not found.**: Conclusions
- Section 8: Declarations

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## 2 Evidence Summary

- 2.1.1 In my evidence, I will deal with all matters relating to EMC for the CSIE Project.
- 2.1.2 I have over 30 years' experience in Electrical and Plant (“**E&P**”) design for railways and I am currently leading a team of specialised designers, with significant experience on EMC. My team and myself normally deliver standard EMC documentation on rail projects to meet Network Rail requirements on EMC. We are competent designers who can properly apply Network Rail's management process for EMC and we can use a set of scientific tools that enable us to assess the impact of the changes that can be brought by a new or an existing system to the electromagnetic environment. Major references from previous projects include (but are not limited to): Holytown to Midcalder electrification project (Scotland), Carstairs junction rationalisation project (Scotland), King's Cross station remodelling, Beaulieu New Station, Old Oak Common station.
- 2.1.3 In section 3 of my evidence, I give a brief overview of the CSIE Project and the key aspects of that Project which are relevant or may give rise to EMC issues.
- 2.1.4 In section 4 of my evidence, I outline the relevant legislation, international and national standards, national and local planning policies and guidance that apply to the CSIE Project regarding EMC. In summary the key relevant legislation is:
- (a) Electromagnetic Compatibility Regulations 2016 SI No. 1091 - (“the **EMC Regulations**”) (**B46**) , and
  - (b) 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 (**B47**).
- 2.1.5 The EMC Regulations were designed to transpose into domestic law the provisions of the Directive 2014/30/EU, and it is to those Regulations that I refer in my evidence.
- 2.1.6 In section 5 of my evidence, I detail the EMC assessments and investigations undertaken to date as part of the CSIE Project and detail the consultation carried out with relevant stakeholders. I also outline the further work proposed in relation to EMC. I note that EMI emissions could increase as a result of the CSIE Project as a result of the intended introduction of electrification changes on the railways
- 2.1.7 Arcadis first issued an EMC Strategy in the early stages of the project. It has been updated at concept design stage as part of the CSIE Project (See appendix 02 of this document). The EMC Strategy sets an overarching process to manage and mitigate
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all EMI risks arising during construction and introduction of changes on the railways and species the relevant directives and standards that shall be complied with.

- 2.1.8 Arcadis also issued an EMC Control plan in the early stages of the project. It has been updated at the concept design stage as part of the CSIE Project (See appendix 03 of this document). The EMC Control Plan is a live document that defines the process by which the new sub-systems are specified and installed. It also defines how the EMI risks which may arise during construction and introduction of changes on the railways, are managed and mitigated.
- 2.1.9 An EMC assessment has been carried out in the form of EMC strategy and EMC control plan as part of the TWAO application (See appendices 02 and 03 of this document). The EMC assessment identifies all sources of EMI emission, establishes the possible electromagnetic coupling mechanisms, determines the EMI interference levels in susceptible apparatus and quantifies the levels of risk.
- 2.1.10 As part of the EMC assessment, an EMC Hazard log has been established during the concept design stage (See appendix 03 of this document). The risks towards third-party equipment were evaluated as moderate at that stage. It was concluded that these could be brought back to tolerable if the appropriate processes that are identified in the EMC Strategy and EMC Control plan (Appendices 02 and 03 of this document) were applied. This shows the following:
- a) The EMC process that was applied was appropriate at that stage of the project;
  - b) The risk assessment covered a wider extent than the railway system itself. Network Rail has identified the EMC-EMI risks to third parties early in the design process, and there was an intent to identify possible mitigation measures to limit the risks of interference as the design would progress.
- 2.1.11 Following submission of the TWAO application, Network Rail engaged with key stakeholders including Cambridge Biomedical Campus (“**CBC**”), University of Cambridge (“**UoC**”), Medical Research Council and the Laboratory of Molecular Biology (respectively “**MRC**” and “**LMB**”). The EMC assessment that has been carried out, and the findings from the coordination and meetings with those stakeholders have shown that additional EMC measurements and studies are required so that Network Rail can provide quantitative evidence of the impact of the project on third-party stakeholders, noting that those stakeholders currently operate EMC sensitive laboratory measurement equipment in the area.
- 2.1.12 In compliance with the findings from those coordination meetings, NR have revised the technical methodology that was initially proposed in the ES (See Appendix 05 of this document) to be implemented which will bring clarity on the EMC issues that have
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been raised. The methodology includes EMI measurements that will be undertaken prior and after construction of the project to formally record the impact of the project. The magnetic field will be calculated over a wide range of frequencies (50 Hz to 150 kHz) for both the pre and post construction situation. In addition, Radio Frequency Interference (“RFI”) measurements are proposed to quantify the levels of radio emission in the background and from the railways. These will be carried out prior and after construction of the project. The results will be assessed against the immunity level of the equipment that is operated by stakeholders to confirm if EMC mitigations are needed or not.

- 2.1.13 The proposed methodology has been discussed with Network Rail and shared with all third parties who may potentially be affected. Arcadis has been commissioned to undertake the work that has been proposed in the methodology document (see our methodology in appendix 05 of this document).
- 2.1.14 In Section 6 of my evidence, I respond to the objections to the CSIE Project that reference EMC issues. The objections are focused on EMI emissions that could increase levels which would interfere with existing EMC sensitive equipment in the neighbouring labs and equipment at the intended introduction of electrification changes on the railways.
- 2.1.15 Other comments from objectors relate to the potential concern of the University that the implementation of the new electrification scheme could alter the electromagnetic characteristics such that excessive levels of EMI that could degrade the performance and functionality of systems operating in the University labs environment.
- 2.1.16 I note the commitments that I am advised Network Rail has offered to the UoC and MRC in relation to ensuring the absence of material adverse effects from EMI upon their assets.
- 2.1.17 In my professional opinion, sufficient assessment has been, and will be, carried out to ensure that the impacts of CSIE Project EMI emissions have been understood and appropriate mitigation designed and secured through the documents that have been provided prior to the TWAO application and after the TWAO application. I consider that, if our methodology for addressing EMC is implemented in full, then the CSIE Project will not have unacceptable adverse impacts in EMC terms.

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## 3 CSIE Project overview

### 3.1 Introduction

3.1.1 The CSIE Project will deliver a new passenger railway station and associated infrastructure required to maintain capacity and train performance. Key elements of this comprise the elements listed in items 3.1.1.1 to 3.1.1.8 below.

3.1.1.1 A new railway station with four platform faces including forecourts, pedestrian and cycle access paths, new interchange for taxi and pick up/drop off points, cycle parking spaces, and limited parking for staff/contractors and blue badge holders, together with associated works. The new station will be located between the Cambridge Biomedical Campus (CBC) and Hobson's Park and bordered to the north by the Cambridge Guided Busway.

3.1.1.2 Introduction of 2 additional loop lines on West Anglia Main Line ("**WAML**") for the purpose of enabling trains to access the eastern and western platforms in the area of the new station and associated Overhead Line Equipment and signalling.

3.1.1.3 Track replacement/modification/additional loop line to the WAML.

3.1.1.4 New Overhead Line Equipment and improvement works at Shepreth Junction and replacement of the Global System for Mobile Communication (Railways) ("**GSM-R**") mast.

3.1.1.5 New permanent rail systems compound and associated works to the south-west of Addenbrooke's Road (Nine Wells Bridge).

3.1.1.6 Attenuation ponds and drainage works.

3.1.1.7 Closure of Duke's No.2 Level Crossing and Webster's Level Crossing over the WAML at Shelford and extinguishment of the existing private access rights over the crossings together with provision of alternative access measures; and,

3.1.1.8 Replacement open space provision.

3.1.2 Full details of the scheme and its component parts are available in the Proof of Evidence authored by Mr Andy Barnes (**NRE1.2**).

### 3.2 Key Aspects Relevant to EMC

3.2.1 Electrified railways and associated traction power supply infrastructure can create sources of electromagnetic disturbances that can propagate towards external systems

through different mechanisms. The Electromagnetic compatibility is the ability of a system:

- a) To operate normally (i.e., with no malfunction) within a given EMC environment without disturbing it.
- b) To operate normally (i.e., with no malfunction) within a given EMC environment without being disturbed by it.

3.2.2 As per Network Rail's general standards on EMC Strategy (NR/L1/RSE/30040) and EMC Assurance Process (NR/L2/RSE/30041)<sup>1</sup>, EMC assessments are undertaken on any project where significant changes are brought to the electrical infrastructure of the railway. Documents compliant to those standards have been delivered as part of the CSIE Project. Details are provided in the EMC Strategy document in Appendix 02 of this document.

3.2.3 The existing railway line has been present for well over 100 years and is already electrified using a 25 kV traction system with Overhead Line Equipment ("**OLE**"). Therefore, it is already a source of EMI. The changes that are proposed by the CSIE Project combined with the nearby developments have resulted in a need to account for the effects of EMI in the area.

3.2.4 The CSIE Project will create modifications to the existing railway lines and the associated traction power supply system. New station infrastructure will be constructed, with significant changes to the existing traction power supply infrastructure. The key considerations relating to EMC are therefore:

- a) What additional levels of EMI are created as a result of the project?
- b) What are the EMI sensitivities of the receivers?
- c) Are any of these of sufficient magnitude to have a significant effect on the receivers nearby?

3.2.5 In response to 3.2.4.b above, the EMI sensitive receptors near to the CSIE Project can be grouped as follows:

- a) Residences near to Shepreth Branch Junction.
- b) Scientific research institutions on the CBC.
- c) Hospital facilities on the CBC.
- d) Residences near to the area of the station development, albeit these are much further away than the more sensitive CBC receivers.

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<sup>1</sup> Network Rail standards NR/L1/RSE/30040 and NR/L2/RSE/30041 are well-known public standards that are normally implemented on UK railway projects for EMC. I have not provided copies, but these can be made available to the Inspector and/or other parties to the Inquiry upon request.



These receptors are shown on Figure 1 below. It is the EMC impact of the Project during its operational phase that is to be assessed.

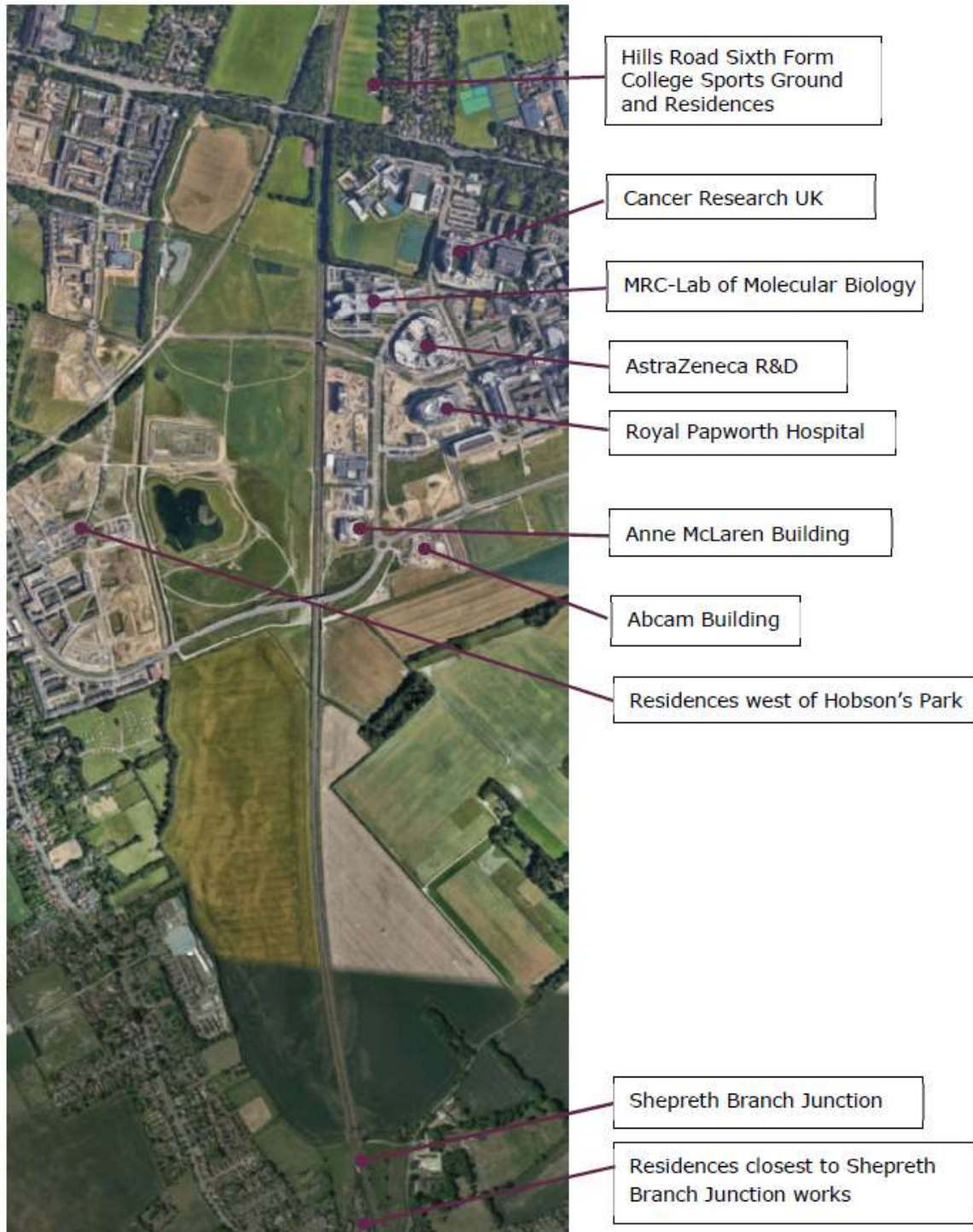


Figure 1. Overview of the area of the CSIE Project development for context

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- 3.2.6 In response to 3.2.4.a above, the area in front of the Papworth hospital and one of the Astra Zeneca buildings will be converted from two tracks to four tracks, and a new station building will be constructed. All new tracks will be electrified. The existing line uses a booster transformer system that is known to limit the emission levels of radiated interferences towards the receptors outside of the railway boundaries due to its physical operation principles. The existing booster transformer system will be retained, however, converting from two tracks to four tracks in the new Cambridge South station area can be considered as an additional source of EMI whose impact on neighbouring stakeholders needs to be assessed.
- 3.2.7 A load demand assessment (See Appendix 04 of this document) has been carried out and has shown that the new timetable that is envisaged will result in an increase of the power demand on the Milton Feeder station that feeds the railway in this area. In addition, trains will start from the new Cambridge South station, which generates additional short-duration (1 to 10 seconds, depending on the type of rolling stock) peaks on the power demand. The EMI is proportional to the current in the OLE wires, therefore, the presence of the new Cambridge South station and the changes that are involved in the trains' operation patterns can be considered as an additional source of EMI whose impact on neighbouring stakeholders needs to be assessed.
- 3.2.8 The neutral section (i.e. the section of OLE that separates two areas fed from two different feeder stations) on the Shepreth Branch junction will be moved by circa 5 metres to the west to accommodate the new location that is proposed for new OLE masts. A movement of 5 meters is considered to have a negligible impact with regards to the length of the entire electrical section (more than 20 km).
- 3.2.9 Based on 3.2.8 above, it has been concluded that the traction power system for the areas outside of the new Cambridge South station will not go through major changes, therefore the corresponding risks have been recorded as low in the EMC risk assessment (See our EMC Control Plan in appendix 03 of this document) that has been undertaken and delivered to Network Rail.
- 3.2.10 In response to 3.2.4.c above, the key parameter of the assessment is the level of immunity from EMI of the equipment that is operated by the stakeholders that are located near the railway. Coordination with stakeholders is currently ongoing to define those levels of immunity, which will in turn enable those levels to be compared against the results from the studies.
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## 4 Relevant Legislation and Policy Context

4.1.1 In this section of my proof of evidence, I present an outline of the legislation and policy context that is applicable to the EMC assessment that has been carried out.

### 4.2 Legislation

4.2.1 The EMC assessment was carried out in accordance with the legislative design documents listed below:

- a) 2014/30/EU, (the European EMC Directive).
- b) 2014/53/EU, European Radio and Telecommunication Terminal Equipment (R&TTE) Directive.
- c) 2013/35/EU, European Directive on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields); and,
- d) The EMC Regulations.

4.2.2 The legislative documents listed above are the overarching EMC requirements that specify the duties to ensure EMC for new projects including (but not limited to) railway projects.

### 4.3 Policies

4.3.1 The following policy documents are of relevance to the assessment:

- a) National Planning Policy Framework (Last updated July 2021) “**NPPF**” (**D1**)
- b) Cambridge (City Council) Local Plan (Adopted October 2018) “**CLP**” (**D6**)”
- c) South Cambridgeshire Local Plan (Adopted September 2018) “**SCLP**” (**D8**)

4.3.2 The NPPF does not mention any particular requirements on EMC, except section 10, para. 116, where EMC requirements are formulated towards local planning authorities so that new telecommunications infrastructure:

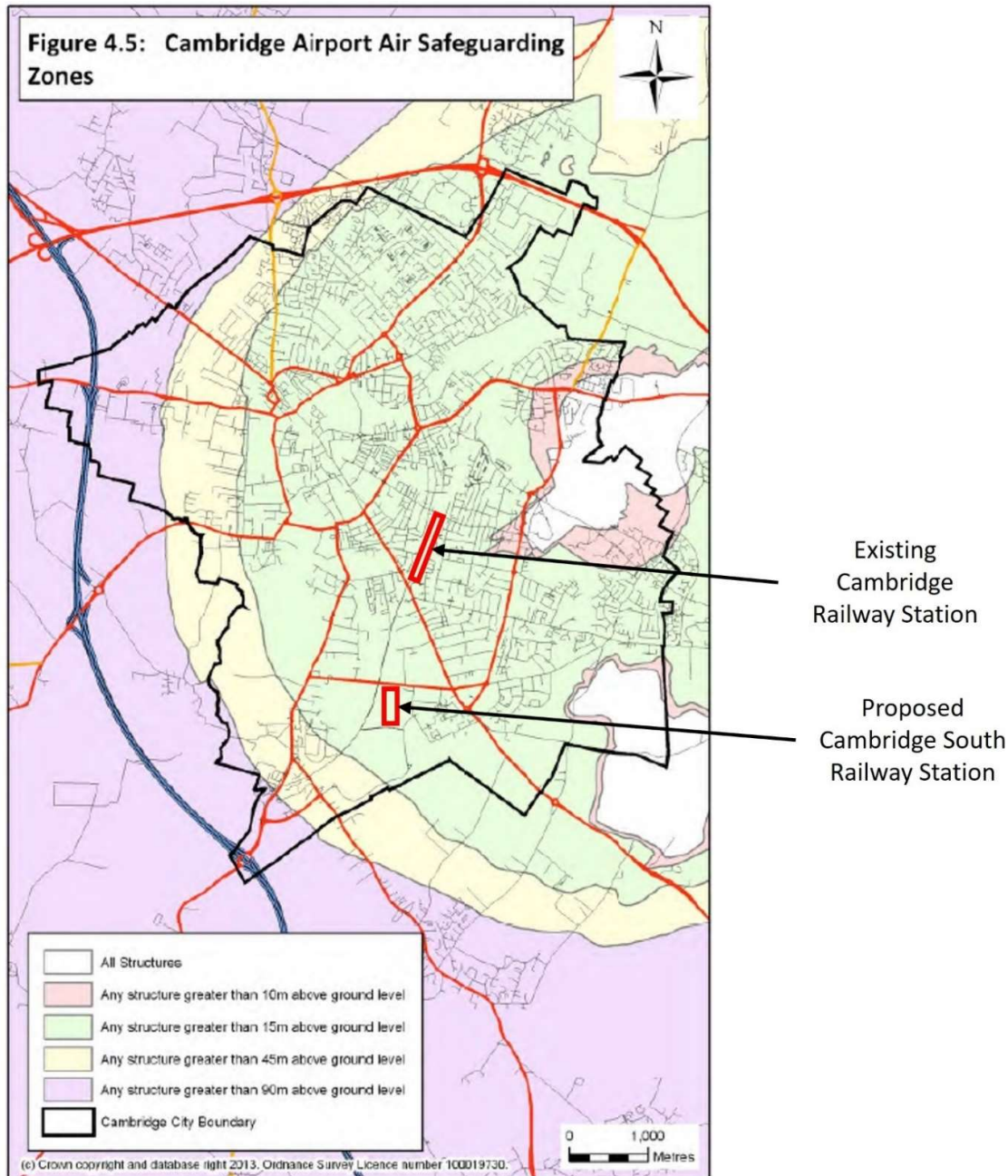
- a) Does not cause significant and irremediable interference with other electrical equipment, air traffic services or instrumentation operated in the national interest; and,
- b) Is planned considering the possibility of the construction of new buildings or other structures interfering with broadcast and electronic communications services.

4.3.3 Those requirements are limited to telecommunications infrastructure, and not directly related to the railway infrastructure at issue in the CSIE Project; however, the risk of EMI to/from neighbouring telecommunication systems has been considered in the risk assessment exercise that has been undertaken on the project.

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4.3.4 The explanatory text to CLP **Policy 37**, para. 4.56 formulates some requirements to maintain the operational integrity of Cambridge Airport's Air Safeguarding zones. Regarding EMC, any developments within the Air Safeguarding zone shall be assessed to ensure the integrity of radar and other electronic aids to air navigation. This section of the Cambridge Local Plan also presents a map of the Cambridge Airport Air Safeguarding zones. The CSIE Project is not within the Air Safeguarding Zone ('**ASZ**') and as such it is not caught by the policy requirement.



*Figure 2. Cambridge Airport's Air Safeguarding zones and railway stations (based on map provided in the Cambridge City Council Local Plan)*

4.3.5 The CLP, **Policy 39**, restricts development that would adversely affect the operation of Mullard Radio Astronomy Observatory. The explanatory text in paras. 4.59 and 4.60 explain that the observatory is of international importance and contains unique radio and optical telescopes that are operated by the University of Cambridge, the University of Manchester and Jodrell Bank. It states:

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[4.59] The telescopes measure signals that are very weak and hence highly susceptible to many forms of interference: specifically to electrical interference; microwave interference from telecommunications masts and equipment; and light pollution and mechanical vibration from domestic, industrial plant and other sources, such as the movement of vehicles, including aircraft

- 4.3.6 However, risk of EMI to the Mullard Radio Astronomy Observatory have been excluded from the EMC assessment that has been undertaken due to the actual distance from the CSIE railway project (More than 5 km). It is noted that the University of Cambridge have not objected to the Project based on any potential impact on the Mullard Radio Observatory.
- 4.3.7 The CLP, **Policy 84**, states that planning permission will be granted for telecommunications development in situations which are broadly in line with NPPF guidance. As mentioned in paragraph 4.3.2 above, the NPPF concerns telecommunications development; however, the risk of EMI to/from neighbouring telecommunication systems has been considered in the risk assessment exercise that has been undertaken for the CSIE Project.
- 4.3.8 The SCLP, **Policy TI/6**, provides that “Within the Cambridge Airport Public Safety Zone, identified on the Policies Map, there is a general presumption against new development or changes of use except for a change of use which could not reasonably be expected to increase the numbers of people living, working or congregating on the land.” The CSIE Project is not within the Cambridge Airport Public Safety Zone.
- 4.3.9 Paragraph 10.36 of the explanatory text echoes the protection afforded to the Cambridge Airport in the explanatory text to **Policy 37** of the CLP (discussed above [4.3.4]). It seeks to protect the integrity of radar and other electronic aids to air navigation for Cambridge Airport’s Air safeguarding zones.
- 4.3.10 The risks to the Airport, as above [4.3.4], have been excluded on the grounds that the CSIE Project is more than 5 km away.
- 4.3.11 The SCLP, **Policy TI/7**, provides a tiered protection to the Lord Bridge Radio Telescope at Mullard Radio Astronomy Observatory, with differing restrictions in Lord Bridge Restricted Area, Consultation Area 1 and Consultation Area 2. The CSIE project is not situated in any of those areas. Paragraph 10.38 of the explanatory text section 10.38 re-iterates the EMC requirement regarding the Mullard Radio Astronomy Observatory at Lord’s Bridge. As above, [4.3.6] Mullard Radio Astronomy Observatory at Lord’s Bridge has been excluded from the EMC assessment that has been undertaken due to the distance from the CSIE railway project (More than 5 km) as set out above, and there has been no objection to this by the University.
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4.3.12 The Emerging Greater Cambridge Local Plan, policy I/SI re-iterates the EMC requirement regarding the Lord's Bridge Radio Telescope. It also mentions existing rail freight facilities and sidings at Duxford, Foxton, Fulbourn and Whittlesford that are all unaffected by the CSIE Project due to the geographical distance and do not therefore need to be considered as part of the EMC assessment.

## **4.4 Guidance**

4.4.1 For the Earthing & Bonding and the EMC assessment, there are a number of standards are recommended to be used as a guidance. As a competent designer, I have recommended the following British and International standards.

4.4.2 I have included a list of the European, British and Network Rail standards that I consider to be relevant this section to this Proof of Evidence. Given the number of such documents and their technical nature, I have not provided copies, but the same could be made available to the Inspector and/or other parties to the Inquiry upon request.

4.4.3 The list of European, British and Network Rail standards that I consider to be relevant this section to this Proof of Evidence is provided in Appendix 01 of this document.

## **5 Work Undertaken To Date and Further Work Proposed in Relation to EMC**

### **5.1 EMC work undertaken**

- 5.1.1 It is important to understand that work in relation to EMC takes place across the whole lifecycle of a project. The EMC work that has been undertaken has been to inform the concept design stage of the project, and has been aimed at delivering the following documents:

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- 5.1.1.1 The EMC Strategy (See appendix 02 to this document). This document was approved by Network Rail on 16<sup>th</sup> November 2021 in CAT2A (See appendix 02 to this document). This means the document has been accepted with amendments that require the appropriate responses with additional information to be submitted to address the comments. The Document Review Notice ('DRN') answers were resubmitted to NR's approval on 05<sup>th</sup> January 2022. The revised document itself will be resubmitted to NR upon acceptance of the DRN answers. Note the document provided in appendix 02 already incorporates the answers to the DRN comments.
- 5.1.1.2 The EMC Control Plan (See appendix 03 to this document). This document was approved by Network Rail on 16<sup>th</sup> November 2021 in CAT2A (See appendix 03 to this document). This means the document has been accepted with amendments that require the appropriate responses with additional information to be submitted to address the comments. The DRN answers were resubmitted to NR's approval on 05<sup>th</sup> January 2022. The revised document itself will be resubmitted to NR upon acceptance of the DRN answers. Note the document provided in appendix 03 already incorporates the answers to the DRN comments. The EMC Control Plan also includes the project's EMC Hazard log that demonstrates that third-party equipment was considered by NR with a level of detail that was appropriate at that stage of the project (Concept design).
- 5.1.1.3 The Load Demand Assessment (See appendix 04 to this document). This document is not an EMC document as such, however, the results from the study that are presented therein clearly show the impact of the future system on the traction power supply system; hence it can be considered as a part of the EMC evidence base. This document is key for the EMC assessment since it shows that the new operation patterns in the area will have limited electrical impact on the traction power supply system when compared to what it is today. This document was submitted to Network Rail on 15<sup>th</sup> December 2021 for approval.
- 5.1.2 Based on my experience from other UK railway projects led by NR, I consider the EMC deliverables listed above have been developed with a level of detail that is appropriate for the current concept design stage. As such, Network Rail has delivered appropriate EMC documents that are relevant to the current stage of development of the project.
- 5.1.3 Additional work relating to EMC that predates the TWAO application was the Environmental Statement (June 2021). Chapter 2 of the Main Environmental Statement identified the scoping information that was sought from campus stakeholders and recognised that there was a risk that the proposed development would have EMC effects on the receptors that had not to date confirmed whether there
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would be implications for EMC effects on their building assets. It was for that reason that the immunisation study (referred to further below) was proposed.

5.1.4 It also demonstrates that the third parties that are currently placing objections on this project were informed by Network Rail at early stage about Network Rail's intent to undertake additional EMC studies to address the third-party issues. Please refer to sections 2.2.18 to 2.2.32 of chapter 2 of the Main Environmental Statement.

5.1.5 In particular, I would like to highlight the following:

5.1.5.1 Section 2.2.19 of chapter 2 of the Main Environmental Statement: the MRC responded to the scoping request to confirm that there would be no impact of the proposed development on their building's laboratory equipment. This shows that the objection from the MRC was raised at a later date, but there was no objection from the MRC when the concept design had been developed.

5.1.5.2 Section 2.2.25: The UoC Estates Division responded to the scoping request to confirm that details of sensitive equipment were provided to NR, and NR noted that further engagement with the Estates division is planned in due course.

5.1.5.3 Sections 2.2.27 to 2.2.32 of chapter 2 of the Main Environmental Statement already proposed that an immunisation study would be undertaken. This shows that Network Rail has been proactive in proposing additional studies that could bring additional assurance on the EMC characteristics of the proposed changes in the CSIE Project area.

5.1.6 Additional objections have been raised following the issue of the Main Environmental Statement, through the TWAO process. A methodology has been proposed to address those concerns (See appendix 05 of this document) to undertake additional EMC studies and measurements and ensure appropriate answers and mitigations will be brought to close those concerns. Further details of this are provided in section 5.5.

5.1.7 Based on all the above, I consider NR has implemented an appropriate EMC methodology that will fully answer the concerns that have been raised if it is developed further across the project's lifecycle.

## **5.2 EMC Assessment of Neighbouring Systems**

5.2.1 Under the European EMC Directive, 2014/30/EU, and the EMC Regulations, Network Rail is required to perform an EMC assessment at the introduction of any changes to the railways.

5.2.2 The EMC assessment ensures that personnel working within the railway environments will be safe and equipment operate satisfactorily. The assessment shall also ensure that equipment and personnel in the railway vicinity, denoted as third-party neighbours, are safe and any adverse EMI effects shall be rectified.

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- 5.2.3 As noted previously, EMC is a subject that needs to be considered over the entire lifecycle of the project. NR has experience of EMC on railway projects and has already delivered a part of the requested EMC information. More EMC deliverables will be delivered during the course of the project.
- 5.2.4 Network Rail's approach at the introduction of any changes is to develop an EMC strategy at the outset of the project and perform EMC Control Plan throughout the life cycle of the project. The EMC Control Plan is a live document throughout the project lifecycle and it usually is revised as the project progresses.
- 5.2.5 The EMC strategy document (See appendix 02 of this document) and the EMC Control Plan (See appendix 03 of this document) are standard documents that are usually delivered on any major Network Rail project.
- 5.2.6 Due to the proximity of sensitive third parties in the area, NR will undertake some additional work on EMC to improve the EMC demonstration. The strategy that is currently in place is based on the following two items:
- a) Undertake specific magnetic fields calculations on a wide range of frequencies to determine the theoretical impact of the proposed changes on the electromagnetic environment. This study is using detailed input data that requests the design to be more mature; therefore, it could not be undertaken to date, but it is expected to start imminently. The results from this study will be added to the EMC evidence base as soon as they will become available. The results from the study will be used to define whether additional protection against magnetic fields is required to reduce the risk of interference on sensitive third-party equipment.
  - b) Undertake EMC measurements before and after the construction works to enable a direct comparison, check the impact of the changes and the effectiveness of the proposed solutions.
- 5.2.7 As part of the EMC strategy mentioned above, a further EMC assessment has been proposed. This will take the form of a report titled "Demonstration of EMC Compliance" and will assess the impact of the new electrification scheme on neighbouring biomedical labs and institutions at the CBC complex. This report is not yet available for issue. However, I will provide an update to the Inquiry should it become available prior to its close.

## **5.3 Issues Raised by UoC and MRC**

- 5.3.1 As noted above, following the issue of the ES, a small number of parties (UoC and MRC) have raised issues about the potential impact of EMC on their assets, which are
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said to be particularly sensitive. It is however understood that the equipment within the CBC currently operate satisfactorily and are compatible with the existing external environment. UoC is concerned that the implementation of the new electrification scheme could alter the electromagnetic characteristics and cause existing electromagnetic levels to be exceeded, both during construction and operation of the scheme.

- 5.3.2 Concerns of EMI emissions have been raised where the new electromagnetic environment could cause excessive levels of EMI and could degrade the performance and functionality of systems operating within the CBC.
- 5.3.3 The implications of adverse EMI emissions for research within the several institutes within the CBC, if they materialise, could include data errors which would lead to interruptions to research and timescales.
- 5.3.4 Further concerns raised by the MRC include the potential for increased electromagnetic interference from the High Voltage (“HV”) cabling which will be located at a close proximity to the LMB and may impact scientific equipment in close proximity to those cables.

## **5.4 Engagement that has been undertaken by NR with UoC and MRC to address the identified issues**

- 5.4.1 Network Rail has engaged with UoC and MRC and is holding regular interface meetings to address their EMC concerns.
- 5.4.2 Network Rail is currently reviewing the technical proposal to undertake the additional bespoke EMC studies and measurements that are proposed in the methodology document that has been issued officially by NR (See Appendix 05 of this document).

## **5.5 Proposal for Addressing Identified Issues**

- 5.5.1 Network Rail has developed proposals for identifying and addressing the potential EMI issues mentioned above, on which the changes introduced by the CSIE Project could result in potential of interference on susceptible equipment in neighbouring institutions. At the time of writing this document, those proposals are currently under Network Rail’s review.
- 5.5.2 The key measures to address these issues will be presented in the “Demonstration of EMC Compliance” referred to previously.

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- 5.5.3 The first step will be to identify existing equipment in neighbouring institutes that are susceptible to EMI emission by conducting a detailed survey. The immunity levels of these equipment will be quantified based on manufacturer's data and engineering judgement.
- 5.5.4 The existing EMI footprint of the existing electrified route of the railway which is close to the CBC will be determined by conducting specific site measurements on strategic locations and performed over several periods of time under different weather conditions to increase the robustness of the results. The results of this test will be used to, firstly validate the modelling/calculations when applied to existing scheme, and secondly to compare the EMI levels after electrification changes are introduced.
- 5.5.5 Theoretical investigation will be undertaken based on the site measurements to determine the new railway characteristics and the new levels of EMI emission after changes are introduced. The theoretical investigation will be undertaken using the results of site measurements before and after the changes are introduced to determine the new characteristics of the system.
- 5.5.6 Prediction of the new EMI footprint will be estimated theoretically using pessimistic assumptions, e.g., number of trains, loading conditions, harmonics distortion, etc. Those assumptions are bespoke to each project and will be formulated appropriately as the design progresses.
- 5.5.7 The predicted EMI emission will then be compared with immunity levels of equipment installed in neighbouring institutes that are susceptible to EMI.
- 5.5.8 The safety and reliability of the equipment will be assured by carrying out a quantified risk assessment and documenting all prospective risks in a Hazard log.
- 5.5.9 Where a risk is identified as unacceptable, further actions will be undertaken to mitigate the risk and minimise it to As Low As Reasonably Practicable ("**ALARP**"). The form and type of actions required in such a circumstance will depend on the nature of EMI and type of equipment in question, and as such it will be assessed on a case-by-case basis. Some actions include (but are not limited to): re-locate some of the HV cables, use shielded cables, use shielding materials that will reduce the emission of magnetic fields, etc.
- 5.5.10 All the mitigation actions and solutions that will be proposed will implement tried and tested measures that have been proven on previous projects (see FCI example in 5.5.12 below), therefore, I have a high level of confidence in their likely effectiveness.
- 5.5.11 Finally, the results of the assessment will be confirmed by conducting site measurements, after commissioning and operating the scheme, on the same strategic
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locations and over the same durations of time as that performed in the initial measurements before changes are introduced.

5.5.12 We have extensive experience in many previous projects with similar issues as for the CSIE Project. Most notably, the challenges encountered for the Francis Crick Institute ('FCI') interface with Crossrail 2 (deep railway tunnel very close to FCI lab), where extremely sensitive equipment are in use. I currently consider that the issues of CBC are less complicated than FCI due to the larger separation distances involved and also due to the fact that extremely sensitive equipment are used in the FCI lab. Furthermore, the Crossrail 2 project uses auto transformer (AT) system, which has a larger power capacity and as such a larger EMI impact on sensitive neighbouring equipment.

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## 6 Response to Objectors

In this section of my evidence, I will respond to those objectors who have raised issues relating to EMC/EMI interference issues in their objections to CSIE. Two objections have been received, the first is from the University of Cambridge Estates Division and the second from the MRC and they are addressed in the following two sections.

### 6.1 Objection – University of Cambridge Estates Division

In this section, I address all the objections regarding the EMI issues that have been referred to in the UoC's Statement of Case dated 14 September 2021 (**E3**).

- 6.1.1 *7.1 Significant concerns with the Scheme have caused the University, following its Objection, to consider further potential effects on [EMC].*

#### NR Response

NR will carry out all the assessment described in section 5 above and implement the necessary measures that will be required to mitigate the risks of the EMC/EMI, which may degrade the performance and functionality of sub systems operating in the neighbouring environment, in compliance with applicable British and European standards and directives.

- 6.1.2 *7.2 The University is concerned that the Scheme could prejudice the functionality of systems within the AMB due to EMI, including systems degradations and loss of functions. The implications of this for research within the AMB could include data errors and interruption to research timescales. Further, potential EMI effects are not limited to laboratory and research equipment – there are also risks of adverse effects on AMB electrical services (for example emergency power supply and lighting).*

- 6.1.3 *7.3 The AMB has been specially designed to accommodate the existing electromagnetic environment. Accordingly, all equipment within the AMB currently operates satisfactorily and is compatible with the external environment. The University is concerned that the implementation of the Scheme could alter the electromagnetic characteristics of the AMB environment and cause existing electromagnetic levels to be exceeded (both during construction and operation of the Scheme).*

#### NR Response

- i. NR will carry out all the necessary measures that will be required to mitigate the risks of the EMC/EMI that could alter the electromagnetic characteristics of the AMB environment in compliance with applicable British and European standards and directives.

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- ii. As mentioned in section 5.5.12 above, we have extensive experience with similar EMC challenges that have been encountered for the Francis Crick Institute ('FCI') interface with Crossrail 2 (deep railway tunnel very close to FCI lab), where extremely sensitive equipment is in use. We currently consider that the wealth of experience that has been gained on the FCI EMC studies is extremely relevant and similar to the current issues that are being raised, which can benefit the AMB.
  - iii. Our current approach is to undertake background EMC measurements prior to construction and calculate the levels of EMC/EMI that can be expected at the location where the equipment is located. Appropriate mitigation measures will be proposed should the results show that the levels of EMC/EMI are exceeding today's levels. Some actions include (but are not limited to): re-locate some of the HV cables, use shielded cables, use shielding materials that will reduce the emission of magnetic fields. All those actions are proven techniques that have been successfully implemented on other projects, hence NR has a high degree of confidence in those solutions.

6.1.4 *7.4 The only mention of EMI/EMC in the ES appears in Chapter 2 (EIA Methodology) in a limited section spanning paragraphs 2.2.18 – 2.2.32 entitled “Electromagnetic Compatibility”. In this EMC section, Network Rail confirms that several stakeholders during informal scoping stage of the Application referenced the possibility of EMI having an effect on sensitive equipment as a result of the overhead line equipment and/or new track associated with the proposed Scheme. Such stakeholders included the Medical Research Council Laboratory and the University. Reference sections that highlight the work we have done 5.1*

6.1.5 *7.5 Network Rail acknowledges in the ES that there remains a risk that the proposed Scheme would have EMC effects on various receptors, including the AMB. The University understands that an immunisation study is proposed by Network Rail at GRIP Stage 4 (between April to December 2021 – see paragraph 2.2.28 of Chapter 2 of the ES) when the outline designs for the proposed Scheme are produced. The University does not know anything further about this study (including whether it has been carried out or not) and Network Rail must share the results with the University as soon as possible.*

## **NR Response**

- i. We confirm the statements in sections 2.2.18 to 2.2.32 of chapter 2 Main Environmental Statement regarding EMC are correct. Since then, an updated methodology has been proposed (See appendix 05 of this document). NR will

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liaise with all stakeholders and will share the findings from the studies and measurements that are proposed and will address all stakeholders' concerns regarding the EMC/ EMI.

- ii. NR will carry out all the necessary measures that will be required to mitigate the risks of the EMC/EMI that could increase EMI effects on EMC sensitive equipment in third party neighbours, including the MRC LMB and the UoC, in compliance with applicable British and European standards and directives.
- iii. The proposed methodology for the EMC work has been established and recently issued to the relevant affected stakeholders. Following that NR will conduct all the necessary communication to address all the stakeholders' concerns.
- iv. I am also advised that heads of terms have been offered to both MRC and UoC committing to mitigate any potential for increased electromagnetic interference from the HV/MV cabling in order that there is no increased impact, above that which is currently experienced, on scientific equipment in close proximity to those cables. As such, both the objectors and the Secretary of State can be confident that there will be no new material adverse EMC effects as a result of the CSIE Project.

6.1.6 *7.6 The purpose of the immunisation study is stated (Appendix A) as being to provide an assessment of the proposed Scheme design to fulfil the following requirements:*

6.1.6.1 *"Verify the earthing and bonding proposed design and demonstrate that the design will mitigate the risks of touch voltages...;*

6.1.6.2 *assess the impacts of the proposed design on signalling and telecom cables...;*

6.1.6.3 *determine the expected magnetic fields along the line..."*

6.1.7 *7.7 As is clear from the above, the requirements set out for the proposed immunisation study are focused only on increasing the protection of the railway assets, including safety aspects. The proposed immunisation study does not take into consideration the EMI impacts on the external neighbouring environment. The immunisation study, as proposed, will have no effect on the EMC interaction between the railway and the outside world, which is of major concern to the University.*

## **NR Response**

- i. The immunisation study is one of three main elements incorporated in the overall EMC assessment. The two other studies include harmonics distortion calculations and RFI quantitative assessment. The immunisation study focuses



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on 50 Hz power frequency, whilst the harmonics distortion assessment is for a frequency range up to 20 kHz which is inherent characteristics of modern railway vehicles. These two studies will be performed quantitatively. The third study will be RFI emissions which will be assessed quantitatively.

- ii. We confirm those studies will take into consideration the EMI impacts on the external neighbouring environment. The University's input to our immunisation study is being sought and the calculations will be tailored to address the specific concerns that have been raised.
- iii. In addition to the above, a revised methodology has recently been issued that includes EMC measurements in the area to cover not only the railway system, but the wider environment.

6.1.8 *7.8 Network Rail has failed to assess or, in the alternative, to provide any assurance in the ES that the EMC/EMI effects associated with the electromagnetic emissions of the railway environment onto the AMB and other neighbouring sensitive receptors during the construction and operation of the proposed scheme will be mitigated.*

#### **NR response**

- i. The ES was an initial statement on EMC that was appropriate at the time it was issued having regard to the level of information available. It also presented a solution for identifying any further implications for EMC in the form of the immunisation study. Since then additional EMC studies have been undertaken and the scope of the study is to be expanded to take into account the concerns raised subsequently.
- ii. We are currently taking all the necessary measures to address all the EMC issues for the whole life cycle of the project. Hence, we will progress our EMC development based on a wider scope of the immunisation studies that will incorporate all the issues that have been raised by the affected stakeholders.

The following key points should be noted:

- a) Network Rail has already delivered EMC documents with a standard level of detail for a railway project of this size, which shows that the EMC/EMI effects of the project have not been underestimated and have been considered from the early stages of the project;
- b) The ES mentioned additional studies to be undertaken and NR has been transparent with all third parties and informed them that those studies would be undertaken



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- c) Network Rail will undertake additional studies and measurements as explained in section 5.5 above and the methodology in appendix 05 to this document, and these will now cover a wider scope based on the feedback received;
  - d) Network Rail will assess the results from those studies and measurements to ascertain the level of risk to third parties. If needed, the proposed design will be amended to reduce the risk of EMI on third party sensitive equipment. As explained above, cable layouts can be revised and shielding materials can be used to limit the levels of EMI if needed.
  - e) All findings will be shared in a collaborative spirit that will benefit all parties.
  - f) As noted above, I am advised that Network Rail has in any event offered legal commitments that they will mitigate any potential for increased electromagnetic interference from the HV/MV cabling in order that there is no increased impact, above that which is currently experienced, on scientific equipment in close proximity to those cables

6.1.9 *7.9 The potential for measures to reduce likely significant EMC effects on the AMB must be considered as early as possible. This is due to the railway environment having different types of electromagnetic sources operating at different frequencies. Railway environments are considered “Harsh” with respect to EMC.*

6.1.10 *7.10 Mitigation cannot simply be left to a Code of Construction Practice (“CoCP”), as is suggested by Network Rail in Chapter 2 of the ES (referred to in paragraphs 2.2.32 and 2.2.49). Notably, there is no mention of the approach to the immunisation study in the CoCP. This omission suggests that the immunisation study will only provide protection to the railway systems (in that the study is limited to addressing EMC / safety interactions within the railway environment only) and has no influence on environmental impact outside of the immediate railway environment.*

## **NR Response**

- i. Please refer to the response for item 6.1.8 above. The immunisation study will include magnetic fields calculations on a wide range of frequencies that cover both railway and non-railway systems.
- ii. Railways are indeed a “harsh” EMC environment; however, we would like to highlight that the electrification has already been existing for a long time in this area. This project is not a new electrification, but a change to an existing electrified railway. Therefore, measurements are vital to get a record of the

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current situation so that it can be used as reference point for future post-construction comparisons.

- iii. We confirm our approach to the studies and measurements that need to be undertaken has evolved since the ES to fully address the further concerns raised by the third parties. As explained in section 5.4 above and the methodology in appendix 05 to this document, and these will now cover a wider scope than the one that was presented in the ES initially.
- iv. In any case, we confirm our intent to include all third-party concerns in our studies and keep all parties informed about the development of the studies and the key findings in a collaborative spirit.
- v. We are not, as suggested, leaving mitigation to a CoCP. Mitigation will be bespoke based on the results of the studies. Network Rail has offered commitments in relation to the outcome of mitigation as described.

6.1.11 7.11 *Preliminary EMC assessments must be undertaken based on worst case assumptions and typical emissions data from railway studies and EMC standards. Electromagnetic site survey measurements must also be undertaken by Network Rail at the boundary of the AMB during the construction and operational stages of the proposed Scheme to quantify the existing electromagnetic environment.*

**NR Response**

- i. Agreed, Network Rail will undertake those assessments. See section 5.5 for details.

6.1.12 7.12 *Mitigation measures will be needed for the sensitive equipment within the AMB, should the levels measured exceed the susceptibility limits of such systems. Such mitigation might need to include electromagnetic shielding of rooms within the AMB or architectural shielding of exterior sides of the building.*

**NR Response**

- i. Noted. The final detail of the mitigation measures is pending upon the results from the studies and measurements.

6.1.13 7.13 *As matters stand, Network Rail has not carried out sufficient assessment work on EMC/EMI effects and has failed to identify any adequate mitigation to address the potential effects of the Scheme.*

**NR Response**

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- i. Network Rail undertook all the EMC measures in the ES requirements and we consider that those measures were appropriate at the time the ES was issued.
  - ii. We are currently implementing a revised EMC methodology that has been established to incorporate all third-party concerns. This methodology has been shared recently.
  - iii. The mitigations – if needed - will be defined once the studies and background EMC measurements will be completed, also considering the level of immunity of the third-party equipment.
  - iv. We trust the objectors will be fully satisfied that there will be no adverse effects from the scheme once the methodology that has been proposed will be implemented on this project.
  - v. In any event Network Rail has offered commitments in relation to the outcome of mitigation as described.

## **6.2 Objection – Medical Research Council**

The MRC Statement of Case (**E4**) raises the following concern about EMI at paragraph 5.8.

6.2.1 *“MRC has concerns about the potential for increased electromagnetic interference from the HV/MV cabling to be located at a close proximity to the LMB which also may impact scientific equipment in close proximity to those cables”.*

6.2.2 *At paragraph 5.30, MRC goes on to request that an electromagnetic study is undertaken.*

### **NR Response**

- i. As described in section 5.5 of this proof, NR will be implementing tried and tested techniques to fully address the current concerns raised by third parties on EMC/EMI issues. As explained in our methodology (See appendix 05 of this document), we are proposing to carry out all the necessary electromagnetic studies supported by site measurements catered to the project specific needs. These techniques are based on our previous experience of a similar nature to the current concerns we have resolved with FCI, we will follow all the recommendations to provide a compliant solution that will satisfy and minimise any impact on the performance and functionality of sub systems operating in

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the neighbouring environment, in compliance with the applicable British and European standards and directives.

- ii. I have referred in section 6.1 above to the commitments that Network Rail has offered.

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## 7 Conclusions

- 7.1.1 NR initially carried out the initial assessments of the EMC requirements for this project at the early stages of the developments.
- 7.1.2 NR has been transparent towards third parties and has proposed additional EMC studies in the ES that were appropriate at the time the ES was issued.
- 7.1.3 The methodology that has been proposed for EMC in the ES has been developed further and its scope has been extended to better address the concerns raised more recently by third parties. The revised methodology has recently been shared (See appendix 05 of this document).
- 7.1.4 As referenced in section 5.4, the EMC will cover the whole life cycle of the project and will address all the EMC concerns that will be developed by any affected 3<sup>rd</sup> party and stakeholder.
- 7.1.5 As described in section 5.5 of this proof, NR will be implementing tried and tested techniques to fully address the current concerns raised by third parties on EMC/EMI issues. As explained in our methodology (Appendix 05 of this document), we are proposing to carry out all the necessary electromagnetic studies supported by site measurements tailored to the project specific needs. These techniques are based on our previous experience of a similar nature to the current concerns we have resolved with FCI. We will follow all the recommendations to provide a compliant solution that will satisfy and minimise any impact on the performance and functionality of sub systems operating in the neighbouring environment, in compliance with the applicable British and European standards and directives.
- 7.1.6 Network Rail has additionally offered commitments in relation to the outcome of mitigation as described.

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## 8 Declarations

I hereby declare as follows:

- 8.1.1 This proof of evidence includes all facts which I regard as being relevant to the opinion that I have expressed, and that the Inquiry's attention has been drawn to any matter which would affect the validity of that opinion.
- 8.1.2 I believe the facts that I have stated in this proof of evidence are true and that the opinions expressed are correct.
- 8.1.3 I understand that my duty as EMC expert witness to the Inquiry to help it with matters within my expertise and I have complied with that duty.

Name

Signature

R. Rasheed Hameed  
Technical Director & Professional  
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7<sup>th</sup> 1 2022



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