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THE NETWORK RAIL (CAMBRIDGE SOUTH INFRASTRUCTURE ENHANCEMENTS) ORDER

REBUTTAL PROOF OF EVIDENCE

ON MATTERS OF NOISE & VIBRATION

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ON BEHALF OF THE UNIVERSITY OF CAMBRIDGE

Inquiry Document Reference	**OBJ-08-W7/REB**
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1 INTRODUCTION

1.1 This Rebuttal Proof of Evidence has been prepared in response to matters raised in the evidence of Network Rail ("**NR**") witnesses Lynden Spencer-Allen on vibration [NR3.1 NR3.2 and NR3.3] and Simon Taylor ("**ST**") on noise [NR4.1 NR4.2 and NR4.3], both of the consultancy company Ramboll UK. I also refer to the evidence of Andy Barnes on Scheme Overview and Construction Management / Methodology [NR1.1].

1.2 In this Rebuttal I set out the current position of the University of Cambridge ("**University**") with regard to certain vibration and noise matters in the light of documents and information currently before the inquiry. Where I have not addressed specific points from the NR evidence, this should not be taken to mean that I accept this evidence. Where NR or other parties produce further evidence by way of rebuttal, I reserve the right to comment on this as necessary.

1.3 The information which the University has received from NR was set out in my main Proof of Evidence [OBJ-08-W7.1] and much of it is repeated in the NR vibration and noise proofs of evidence. Since submission of the Environmental Statement ("**ES**") and Statements of Case there have been virtual meetings held on a without prejudice basis on noise and vibration, and there has been an exchange between NR and the University with regard to draft heads of terms of an agreement between them as referred to in 9.3.6 of Lynden Spencer-Allen's proof (NR3.2), and I have also had an email exchange with him following receipt of his main Proof of Evidence concerning mathematical issues in calculations he relies on.

2 CORRECTION TO MY MAIN PROOF OF EVIDENCE [OBJ-08-W7.1]

2.1 The third and fourth sentences of paragraph 6.22 of my Main Proof are incorrect as printed. Reference to "0.1g" should be reference to "4mg", and reference to "256 mg" should be reference to "256 μg".

2.2 With regard to vibration effects on rodents and fish, while some conclusions derived from the scientific literature are stated in terms of overall acceleration in units of g, the University selected the design criterion in terms of VC-A. The relationship between VC-A and values expressed in terms of g depends on the bandwidth of the vibration. Broadband vibration with amplitude just equal to VC-A at every frequency from 8Hz to

80Hz would amount to approximately 4mg. Vibration at a single frequency at 8Hz just reaching VC-A would be 256 µg.

3 SUMMARY OF THE UNIVERSITY'S CURRENT POSITION IN THE LIGHT OF NR's EVIDENCE

3.1 It is common ground that **construction phase activity** has the potential to cause significant adverse effects during works closest to the AMB (6.2.1 of LSA Summary NRE3.1). Paragraph 1.19 of ST's summary (NRE4.1) reports that construction noise is considered to have significant adverse effects on the AMB receptors. It is also common ground that **operational noise** will not cause significant effects on AMB receptors.

3.2 ST qualifies his statement about significant construction noise effects on AMB by saying (NRE4.1 1.20) that this will not result in significant adverse effects upon research activities or the behaviour of animals housed in the buildings. I respond in this matter below.

3.3 LSA qualifies his statement about construction vibration effects by saying (NRE4.2 9.3.4) that he considers that minor exceedances of the University's vibration criterion for animals (VC-A) are not likely to be detrimental to the animals and research being undertaken based on empirical experience of construction near to similar facilities. He notes that NR have proposed draft Heads of Terms for a legal agreement with the University which commits that construction activity would not exceed the VC-A and VC-C levels within the relevant areas of the AMB except when agreed otherwise, but this proposal involves much longer averaging times than the University can accept. This issue is explained in detail in my main proof of evidence (OBJ8-08-W7.1)

3.4 Effects which have not been considered by NR include the effect of high frequency sound and infrasound on rodents and underwater sound on fish. These considerations are necessary because testing of rail and rail welds with low-frequency ultrasound (i.e. sound at frequencies within the hearing sensitivity of rodents) is a frequently used process, and underwater sound is the way in which vibration affects fish.

3.5 With regard to **operational vibration**, LSA states (NRE3.2 9.3.1) that "No significant adverse impact is predicted for the operational phase". This is an important area of disagreement which I discuss below.

3.6 The University have set out **acceptability criteria** for noise and vibration that, if satisfied, will not significantly harm either the use of sensitive laboratory equipment, or the environmental conditions of the animal receptors (rodents and fish), and will not have significant adverse effects on the working environment of human beings in the AMB. These criteria are listed in 7.12 of my main proof of evidence (OBJ-o8-W7.1) and in the University's response to NR's draft Heads of Terms. NR's response to these criteria is awaited.

4 MY DETAILED RESPONSE TO NR'S VIBRATION AND NOISE EVIDENCE

Vibration – Sensitivity of the receptor and baseline measurements (NRE3.2 6.3.1)

4.1 It is explained here that vibration from freight trains, previously scoped out in the ES, has now been considered, using measured results from two freight trains. The class of locomotive and wagon type and number is not reported, nor which track they were on nor whether they were laden or unladen, nor what their speeds were. Consideration of variations in these parameters and their effects on the predictions and conclusions is not provided. Network Rail have therefore not fully assessed the baseline in relation to vibration.

Vibration – Construction stage impacts (NRE3.2 6.3.2)

4.2 Mr Spencer-Allen presents construction vibration predictions using sources which express vibration in terms of Peak Particle Velocity (PPV). He therefore makes a conversion between PPV and VC curves. Ramboll uses 0.19mm/s PPV as an equivalent to VC-A. This assumes that the vibration is spread across seven 1/3 octave frequency bands (page 123 of LSA Appendices NR3.3). While that may occur, it is also shown on the same page that if the vibration were spread across four 1/3 octave bands the equivalent would be 0.14 mm/s, and it must be borne in minds that it may only occur in one 1/3 octave band, in which case the equivalence would be 0.07 mm/s.

4.3 While it may be the case that general construction vibration can be spread across several bands, in this case there are proposed sources that generate vibration at very few frequencies. For example, vibration from a ballast tamper is likely to be predominantly concentrated in one frequency band only. The consequence is that the PPV value equivalent to either the VC-A or VC-C curve will be 2.7 times stricter. In other words, the figure of 0.38mm/s stated in Table 5.1 (see paragraph NR6.3.2.12 and p32 of NRE3.3) as equivalent to VC-A becomes 0.14mm/s and the 0.1mm/s figure stated as equivalent to VC-A on upper floors (and VC-C at ground floor) becomes

0.04mm/s. Table 5.1 revised in this way then shows exceedance of VC-A in all four rows under “Vibratory compaction (start-up and run down)”. In the same way, the first two rows under “Vibratory compaction (steady state)” show exceedance of VC-C at ground floor and all four rows under “Vibratory compaction (start up and run down)” show exceedance of VC-C at ground floor.

4.4 In Technical Note 5 vibration predictions are presented for sources not considered in the ES, including compaction equipment/vibratory rollers. The predictions are for free-field and, based on measurements made by Ramboll with regard to the AMB, they have used an outside-to-inside conversion factor of a half for the ground floor, but vibration on the first floor is taken as equal to the free-field level, partially allowing for the amplification due to resonant responses of the first floor structure. Figure 13 of NR3.2 actually shows amplification much greater than has been allowed for. The explanation given is “*This amplification is only partially due to resonant effect at upper floors as local sources on the upper floor can appear as an amplification from ground floor levels but are actually directly applied forces*.” However, the truth of this hypothesis has not been established.

4.5 Mr Spencer-Allen presents results (Page 30 of his Appendices NRE3.3) based on a free field PPV of 0.1 mm/s being equivalent to VC-C at the “Imaging” location, 0.38mm/s free field being equivalent to VC-A in the ground floor research area and 0.19mm/s mm/s being equivalent to VC-A in the upper floor research areas.

4.6 There then follows a table of predictions results in terms of free-field PPV. Of note is a prediction of 0.18mm/s for “Vibratory Roller”, which is not the figure which is arrived at using the parameters and equations reportedly used, namely 0.46 mm/s. In response to my email question on this point Mr Spencer-Allen’s reply was “*I have checked with my colleagues and there was a reduction factor we applied for the source levels for the vibratory roller for the California Transport model. This was done to provide some correction for limiting the size of compaction equipment rather than the single value in that methodology. However, I agree this wasn’t made clear in the technical note and I think we should have just omitted from the table the vibratory roller data for the California Transport model as we have the data from BS5228 (steady state and run-up/down). Given the planned careful selection of compaction equipment, the California Transport source data is too high and so using the BS5228 approach is the most appropriate and for which the results are in line with the code and most appropriate for the assessment.*”

4.7 The same issue arises with regard to works in the station area at 150m distance. The correct prediction for the vibratory roller is 0.11mm/s, which is above the start of the range of VC-A equivalents of 0.07-0.19mm/s which I have explained above.

4.8 Table 5.1 on page 32 of Mr Spencer-Allen's Appendices (NRE3.3) is therefore, as printed, misleading (irrespective of the PPV conversion issue I identify above), and it must be concluded that only mitigation by control and/or limitation of types or sizes of plant is used if significant exceedance of protection criteria to be avoided. Insofar as the columns in Table 2 giving results using the method and data in British Standard 5228 are to be relied upon, then subject to my issue with the PPV conversion, it would be appropriate for equipment to be limited to that which was consistent with the relevant data in the British Standard.

4.9 Mr Spencer-Allen's proof of evidence at NRE3.2 6.3.2.21 states "*For the ground floor VC-C area the expected reduction of vibration levels into the building is between 2 and 4 times and hence allowable PPVs of 0.07-0.2mm/s. The VC-C area is 90m from the closest track works and this range is compared to the values within the second row of the table. It is seen that the activities are within the range. There is therefore a risk that some activity could exceed the VC-C level marginally.*" However, even this assessment ignores the PPV conversion issue I have identified above, along with the concerns relating to the vibratory roller prediction that I have also mentioned. This means that it cannot be said that any exceedances of VC-C would only be marginal.

Vibration - Construction stage mitigation proposed (NRE3.2 6.3.3)

4.10 No specific mitigation measures are described, with only generalizations about best practice approaches being made. Without specific mitigation measures, the effects on the operation of the AMB cannot be assessed in appropriate detail, which is why the University has proposed key criteria to NR in revised heads of terms for a legal agreement and/or Protective Provisions on the face of the Order.

4.11 Paragraph NRE3.2 paragraph 6.3.3.4 contains the statement "*One published paper referenced in the UoC Statement of Case (Core Document ref E3) sets out a vibration threshold which should not be exceeded. This threshold is also higher than VC-A by a factor of between 2 and 10 times at different frequencies. It is therefore considered unlikely that some exceedance of VC-A would result in harm provided the exceedances are not above the limits within the published paper*."

4.12 This aspect of the NR evidence is predicated on an assumption that some exceedances of VC-A could be accommodated because exceedances of 0.025 g can be taken as some sort of benchmark for harm. However, I do not accept this analysis. The figure of 0.025 *g* is found in recommendations by Jeremy G Turner (**OBJ-08-W7.1** page 72) "*Likewise, vibration levels of only approximately 0.025 g have been shown to increase fecal corticosterone metabolites in female (but not male) mice, and to result in overt behavioral responses in female mice indicative of arousal*." It is therefore desirable to set vibration limits at levels lower than 0.025 *g* when that is the point at which these metabolic and behavioural responses occur. Further, there is other evidence identified by myself and Karl Wilson that suggests a lower criterion of 50 µm/s should be applied. It would therefore remain my advice that the University's selection of VC-A as a criterion is appropriate in the circumstances. In any event, the Rebuttal Proof of Evidence of Karl Wilson comments on the credibility of NR relying on the conclusions of this single research paper in general terms.

Vibration - Operational phase impacts (NRE3.2 6.3.4)

4.13 The conclusion that vibration from freight trains is not likely to exceed VC-C is based on an allowance for a speed reduction on the nearer loop line to offset the reduction of distance to the AMB. This allowance is based on the assumption that freight trains travel at the "line speed", which NR state shall be 90 mph on the main line and 60 mph on the loop lines. However, freight trains do not travel at the line speed of 90 mph on the main line, and their speed is likely to be little different on the main line and the loop line, which is to be constructed with a high-speed turnout. Vibration levels are speed-dependent, and Mr Spencer-Allen relies on a drop in vibration on the loop line due to a lower speed in order to offset the increase in vibration due to a shortening of the distance between the AMB and the loop line and the slewed main line. The speed ratio assumed (60/90 mph) is not realistic and the calculation of the vibration reduction associated with it is not likely to occur. NR should therefore take the difference between the distance of the current and the distance of the proposed new track layout from the AMB as the basis for assessing vibration impacts, as the reductions in speed referred to by NR cannot be relied upon in terms of "off-setting" against great proximity (and the same applies in relation to the assessment of noise effects).

4.14 It is explained in the main Proof of Evidence of Andy Barnes in para 334 (NRE1.2) that NR are proposing to run trains on the loop lines at up to 90 mph as a temporary measure. The period of temporary track layout is not clear, but during that time one loop line and one main line will be operated as if they were two main lines. During this

phase speeds on the two tracks, one loop line and one main line, will be the same as on the pre-scheme main line with no offsetting of the shorter distance by speed reduction.

4.15 LSA does not assess the effect of two freight trains passing simultaneously.

Vibration - Construction works on the AstraZeneca Site (NR3.2 8.2.6.6)

4.16 At 8.2.6.6 of his main proof of evidence, (NRE3.2) Mr Spencer-Allen refers to construction work on the AstraZeneca site to the north of the AMB. This work is for the erection of a car park structure, but the nature of the construction work does not involve such items as vibratory rollers. I understand from the University that Astra Zeneca implemented its own mitigation (as I would expect) and that the work carried on within the AMB has not been disrupted.

Vibration - Plot 9 (NR3.2 8.2.6.8)

4.17 At NR 3.2 8.2.6.8 Mr Spencer-Allen refers to what is known as Plot 9 in the context of there being future vibration from construction work there potentially affecting AMB. It is not uncommon for building work to take place on research campuses, and because the work is more benign than the construction of a railway, and is wholly within the control of the potentially affected facility, it is possible for the two to coexist successfully.

Noise – Lack of consideration of mitigation (NR4.2 10.3.2 and 10.3.3)

4.18 The inspector is asked to rely on the firm opinion of Simon Taylor “that appropriate BPM mitigation is proposed to limit construction noise at the façade of the AMB, so that effects to research activities (including effects upon behaviour of animals) are prevented. Therefore, there is no reason to consider further mitigation.” This is not a matter of opinion, but of established engineering practice, and that sufficient prediction work should be carried out to demonstrate that adequate practicable mitigation is available. Predictions should be carried out in sufficient detail, floor-by-floor, including specific mitigation so as to demonstrate that adverse effects will not occur. These predictions have not been provided, and so the University has had to indicate to NR the key criteria that would have to be met.

Noise – Effects on sensitive equipment, animals and internal criteria (NR4.2 10.3.5)

4.19 The basic thesis advanced by ST (NR4.2 10.3.6) is that there will be no significant effect because maximum construction noise levels will be at a lower level and less frequent than the pre-existing maximum noise levels, understood to be from passing trains.

4.20 Paragraph NRE4.2 paragraph 10.3.31 states

"*Noise levels from construction activities associated with the CSIE Project are predicted within the CSIE ES chapter 5 to be up to 72 dB with no mitigation at all. This is predicted to reduce to 67 dB LAeq,10 hours at the façade of the AMB following Best Practicable Means (BPM), plus the inclusion of solid 2.4m site hoarding and localised screening of particularly noisy activities such as cutting, breaking of concrete and piling rigs.*"

4.21 Inspection of Chapter 5 indicates that this prediction is for construction works in the station area. Predictions for track construction are not provided here.

4.22 The figure in NRE4.2 at paragraph 10.3.31 appears to be at odds with the statement in paragraph 10.3.6. While that statement is given in terms of maximum noise level, the words "a lower level and less frequent than the pre-existing maximum noise levels" lead to the unavoidable conclusion that the construction noise L_{Aeq} levels would also be less than that those due to trains, since if level and frequency of occurrence are reduced, L_{Aeq} levels must go down unless the construction events were of much longer duration. The predicted construction noise L_{Aeq} (i.e. 67 dB L_{Aeq}) is much higher than the existing L_{Aeq} level (56.8 dB L_{Aeq} - see in the ES at NR 16 Volume 2 Chapter 5).

Noise - Façade sound insulation (NRE4.2 10.3.8-10)

4.23 While I do not disagree with ST's assumption of a façade sound reduction of about 35 dB(A), this applies only to A-weighted sound. As I explain in my main proof (OBJ-08-W7.1) it is also necessary to consider ultrasound with regard to the hearing sensitivity of rodents, and ultrasonic testing equipment is commonly used to test rail and welds. Although very short wavelength sound is better able to penetrate small openings, it may be that the façade sound insulation is adequate at ultrasound frequencies, but no assessment has been made.

Noise - Predicted construction noise levels (NRE4.2 10.3.13-30)

4.24 Predictions are presented for noise from works in the station area and from works on track construction, including foundations for the overhead line equipment gantries for

which the result of 80 dB L_{AFmax}. This is compared with the regular external baseline L_{AFmax} levels of 83-88 dB L_{AFmax}. The point is similar to that discussed under NR4.2 10.3.5 above.

4.25 The predictions at the façade of the AMB, which are height sensitive due to the varying performance of noise barriers according to the extent to which the top of the barrier protrudes above the line-of-sight, are still given as single figures. Predictions are required for each floor level taking into account the lower barrier noise reduction at higher floors. The absence of these predictions means that the full effect of construction noise on the AMB cannot be assessed.

5 LACK / RELIABILITY OF INFORMATION PROVIDED BY NR

5.1 Specific information which NR has not provided to date includes:

5.1.1 a preliminary construction programme to enable times, durations and locations of noise predictions to be made at each of the AMB floor levels;

5.1.2 predictions of vibration and noise from operation during the temporary track layout phase;

5.1.3 evaluation of uncertainty, particularly in the freight train vibration assessment;

5.1.4 predictions of underwater noise levels for fish;

5.1.5 consideration of ultrasound (e.g. from ultrasonic rail testing) with regard to rodents;

5.1.6 predictions of vibration from ballast tamping; and

5.1.7 an adequately detailed protocol for monitoring and control of vibration and noise.

5.2 Additionally, parameters on which existing assessments have been predicated need to be ensured, including:

5.2.1 minimum distances from rail joints to the AMB;

5.2.2 minimum distances from rail crossings to the AMB;

5.2.3 minimum radii of rail turnouts;

5.2.4 speed limits of freight trains in the temporary and permanent track layouts;

5.2.5 avoidance of vibratory or impulsive pile insertion; and

5.2.6 limitation of vibratory roller properties.

6 CONCLUSIONS

6.1 Some of the deficiencies of the ES have been addressed (including partial addressing of freight train issues, partial addressing of construction activities, some additional information regarding gantry construction and overhead line etc). However, NR have not carried out a full assessment of all potential effects on sensitive receptors in the AMB. The University has therefore set out acceptability criteria which are achievable although work is required to establish the extent of the required mitigation and to develop a workable and reliable prediction, monitoring and control protocol.

6.2 The predictions presented in the evidence are all predicated on sets of assumptions, all of which are subject to significant uncertainty. Some are presented incorrectly. There is as yet no draft construction programme with associated plant teams with timings and durations, such that where there is a risk of exceedance of the University's criteria, it is not possible to evaluate the consequences or the extent of disruption to research undertaken in the AMB.

7 WITNESS DECLARATION

I hereby declare as follows:

7.1 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.

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

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

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