Assessing HS2 Noise Nuisance in Cubbington Parish

A paper for consideration by the Offchurch and Cubbington Community Forum

Cubbington and its setting in a tranquil environment (photo: Frances Wilmot)

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Acknowledgements

The author of this paper is aware that, although he is a Chartered Engineer, he is not academically or professionally qualified as an acoustician. The critique in this paper must, accordingly, be regarded as the efforts of an “amateur” in the field.

The comments within have, however, been extensively researched and are based upon work by many professional acousticians. In particular, the author wishes to acknowledge the submissions made to the public consultation on HS2 by Southdowns Environmental Consultants Ltd (on behalf of 51m) and Professor Colin Waters (for the Chiltern Countryside Group). These two excellent documents have proved a rich vein of knowledge, which the author has mined extensively in producing this submission.

The author also wishes to acknowledge the impetus that the early paper on high-speed train noise produced for the Ladbroke Action Group by R J Bennett gave him to take up an interest in this topic.

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A Note on Recent Developments

When this document was nearing completion the draft document *HS2 London to West Midlands EIA Scope and Methodology Report* was issued for consultation. This document makes proposals that differ in part from the methods adopted for the Appraisal of Sustainability, and which, to a limited extent, addresses suggestions made in this submission.

This current submission was well advanced and to incorporate the contents of the EIA scoping document would have required a substantial rewrite. In view of this and the possibility that aspects of the EIA scoping document would change following the outcome of the consultation, the decision was taken to ignore the EIA scoping document for the purposes of this submission, which only considers documentation issued in January 2012 or earlier.

However, we wish to note the following changes in methodology proposed in the EIA scoping document that have an impact on the contents of this submission:

- The EIA scoping document adopts the World Health Organisation (WHO) night noise guideline (NNG), as suggested in section 5.3 of this submission.
- The EIA scoping document employs the maximum sound level of a train pass-by as one of the metrics to assess noise nuisance, as suggested in section 5.2 of this submission. However, the threshold for this metric has been set so high that it is likely to be ineffective.
- A “semantic scale” of severities has been introduced, which addresses the suggestion made in section 6.5 of this submission that the “grey dot” band should be subdivided to provide a better indication of the magnitude of the noise nuisance impact.
- Some commitment to undertake field surveys of baseline noise levels is given in the EIA scoping document, but this may not be sufficient to provide the verifications suggested in section 6.2 of this submission.

Aside from these identified issues the suggestions in this submission are unaffected by the contents of the EIA scoping document.

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1. Introduction

The report that summarises the responses to the public consultation on HS2 tells us that, in response to Question 6:

"There are 3,046 respondents who express the opinion that either the noise assessment is inadequate, or more information about it needs to be provided. A total of 2,945 respondents are generally concerned about the noise a high speed rail line will generate."[1]

A smaller number of respondents made similar comments in response to Question 5.

HS2 Ltd acknowledges that "noise attracted a significant number of comments in response to the consultation, in particular the predicted noise levels and the prediction methods".[2]

HS2 Ltd informs us that it is "aware of the concern communities that are alongside the proposed route for HS2 have regarding noise".[3]

This concern is felt very strongly by the residents of Cubbington. More than two years after first learning that the preferred route for HS2 cuts through our parish, estimated noise nuisance levels from high speed trains that we can each expect to have to endure at our dwellings have not been advised. The only exception to this is the small number of properties graded with grey or yellow dots on the *Residential Airborne Noise Appraisal Maps* that were included in the Appraisal of Sustainability (AoS)[4].

The Cubbington Action Group against HS2 does not consider that the information on noise provided in the AoS comes anywhere near to satisfying the reasonable expectations of Cubbington residents and are pleased to note the commitment that has been given by HS2 Ltd to undertake further work as part of the Environmental Impact Assessment (EIA):

"… the EIA would undertake more detailed and localised assessment of noise and this could allow for the production of detailed noise analysis and detailed recommendations for future noise mitigation"[5].

This assurance, if that is what it is, is welcome. However, the use of the phrase "and this could allow" is somewhat worrying; we hope that this does not imply any doubt that the noise nuisance estimates that residents require, and that the design of effective noise mitigation will demand, will be made available.

Whilst the Cubbington Action Group against HS2 expects that HS2 Ltd will formulate a single policy for assessing and mitigating noise nuisance that will apply to the whole route, noise will remain an issue of great local importance. We therefore feel that it is appropriate for us to present our thoughts on how noise nuisance might be assessed and presented to our community within the EIA process, and that the Offchurch and Cubbington Community Forum is the appropriate working group for us to table these thoughts, at least initially.

Further, it appears that the Offchurch and Cubbington Community Forum is the only formal interface with HS2 Ltd that is currently available to the Cubbington Action Group against HS2, although we would naturally be pleased to discuss our requirements on noise nuisance information bilaterally with HS2 Ltd or jointly with other stakeholders involved, if this should prove more convenient or expedient.

The scope of this submission is limited to considerations of airborne noise from train pass-bys, since this source of noise was the only one considered quantitatively in the AoS. However, other potential sources of noise nuisance are identified in the AoS and these will require separate consideration.

2. Summary of Suggestions

This paper makes a number of suggestions to be considered in the formulation of a policy for estimating and presenting airborne noise nuisance impact assessments to the residents of Cubbington, and in the design of efficient noise mitigation measures. Where these suggestions appear in the text of this paper, they have been highlighted by **bold** font. For convenience, they are also presented in this section, together with a reference to the section of this paper in which the suggestion is made (in parenthesis).

Our suggestions are that:

- HS2 Ltd clarifies the assumptions that have been made about mitigation in order to produce the *Residential Airborne Noise Appraisal Maps* in section 3.5 of Volume 2 of the AoS, including identifying the level of noise reduction that has been assumed (section 4).
- Noise contour mapping be prepared and published as a matter of urgency for a study area 3km either side of the whole of the proposed route (section 4).
- HS2 Ltd clarifies if noise contour mapping will present HS2 sound levels expressed relative to the background noise level (section 4).
- Noise contour mapping employs the day-evening-night equivalent continuous sound level, L_{den} (section 5.1).
- Noise contour mapping is also produced using the noise metric L_{Amax} and this parameter is taken into account in any noise nuisance thresholds or limits that are set (section 5.2).
- Noise contour mapping is also produced using the noise metric L_{night} and this parameter is taken into account in any noise nuisance thresholds or limits that are set (section 5.3).
- A policy for complying with the NNG, at least in the long term, is developed by HS2 Ltd and any reliance on IT as a stop-gap identified (section 5.3).
- A review is carried out of whether the sole use of the metric L_{night} will provide a reliable estimate of night-time noise nuisance and effects on sleepers to be made (section 5.3).
- A review is carried out of whether the use of A-weighted metrics will provide a reliable assessment of noise nuisance to be made, and to determine if an adjustment should be applied to estimated sound levels (section 5.4).
- A policy is developed by HS2 Ltd for “future proofing” any information provided on noise impacts on dwellings, in order to accommodate any foreseen changes in traffic levels (section 5.5).
- All sound levels should be expressed as free field measurements (section 6.1).

- A programme of field measurements of existing sound levels is carried out, in order to verify whether the background noise levels in areas "where predicted existing rail noise levels are low or there is no rail traffic" may be assumed as 45 dB $L_{Aeq,18hr}$ (section 6.2).
- A review is carried out to determine if the assumption of a minimum value for the nuisance threshold of 50 dB L_{Aeq} is appropriate (section 6.2).
- A review is carried out to determine if designating a "high noise level" (red dot) band is justifiable or appropriate (section 6.3).
- Consideration is given to ways in which a maximum noise exposure limit could be applied to HS2 (section 6.4).
- The "noticeable noise increase" band used to identify dwellings affected by HS2 noise should be subdivided to improve the usefulness of the classification to property owners (section 6.5).
- A policy for achieving a robust and proven noise propagation model for the EIA, either by adapting the CRN or by employing an alternative model, is developed by HS2 Ltd (section 7.1).
- HS2 Ltd clarifies the adaption that was made to the basic CRN model to carry out the calculations for the AoS (section 7.1).
- Either noise calculations should be made at the maximum design speed of each track section or, failing that, at the initial operating speed. The latter option should only be exercised providing that a binding and irrevocable guarantee is given that any subsequent increase in operating speed will only be permitted when it can be demonstrated that it will not increase noise nuisance levels at any location (section 7.2).
- A review is carried out of the technical risk associated with claiming a 3 dB(A) reduction in train source noise for anticipated noise control improvements in the next generation of high speed rolling stock (section 7.3).
- The treatment of any assumed reduction in train source noise as contributing to the mitigation budget is reconsidered (section 7.3).
- A review is carried out to determine if it is appropriate to apply a correction to increase the noise source level to account for track quality degradation during normal operation (section 7.3).
- HS2 Ltd clarifies how it intends to establish whether aerodynamic noise sources higher up the train may be reduced sufficiently by design improvements or whether higher noise barriers will be required (section 8.4).
- HS2 Ltd commissions tests to evaluate the effectiveness of different noise barrier designs and heights at 360 kph and 400 kph at least (section 8.5).
- HS2 Ltd clarifies how the level of noise mitigation provided by cuttings and bunds will be assessed (section 8.5).
- A policy is developed by HS2 Ltd for verifying mitigation measures and rectifying any installations that do not satisfy predicted performance (section 8.5).

- HS2 Ltd clarifies what assumptions have been made in estimating the level of noise mitigation that will be achieved, and what contribution to the overall total has been assumed from each mitigation mechanism (section 8.5).
- A specialist group is set up to report to community forums on noise issues (section 9).
- Legislation that will apply to HS2 and future high speed train projects is introduced by HM Government to enforce a legal limit on noise nuisance levels (section 9).
- HS2 Ltd should set up a new expert body to review and scrutinise the standards to be used to estimate and assess the noise nuisance caused by HS2. More than half of the membership of this body should be demonstrably independent from Government, HS2 Ltd and contractors to HS2 Ltd (section 9).

3. Expectations

The Cubbington Action Group against HS2 desires that the information on airborne noise nuisance to be provided by HS2 Ltd shall at least allow any resident of Cubbington to be able to obtain an estimate of the incident noise level from HS2 at the most exposed façade of that resident's dwelling. We have the following expectations for this noise nuisance information, which are identified as six numbered criteria:

- The method of presentation should allow the estimated incident noise level to be determined for any location where HS2 noise is likely to be evident (Criterion 1).
- The method of presentation should allow the estimated incident noise level to be determined to an accuracy of about 3 dB(A) (Criterion 2).
- The parameter, or parameters, in which the estimated incident noise level is expressed (the "noise metrics") should provide a good indication of the degree of noise nuisance that the noise will cause (Criterion 3).
- The information should reflect the generally-agreed concept that the nuisance value of the same noise level will be increased during the evening and night periods (Criterion 4).
- The algorithm employed to estimate incident noise levels should be proven for use in predicting noise levels from high speed trains, and should be demonstrated to be accurate (Criterion 5).
- The impacts of any noise mitigation measures employed should be accurately reflected in the estimation of incident noise levels, including any variation of noise barrier mitigation across the audio spectrum (Criterion 6).

4. Presenting the Information

Every year the Environmental Research and Consultancy Department (ERDC), Directorate of Airspace Policy of the Civil Aviation Authority produces a report on behalf of Heathrow Airport Ltd[6]. This report presents a picture of the noise nuisance caused by aircraft movements over the previous year for dwellings in the vicinity of Heathrow Airport.

The method chosen by ERDC to present this information is a series of noise contour maps; noise contours are lines joining places of constant level of the chosen noise

parameter, akin to the height contours shown on geographical maps or isobars on a weather chart.

It appears that HS2 Ltd had originally intended to provide HS2 noise contour maps to inform the public consultation – at least the Secretary of State for Transport of the day, Philip Hammond MP, appeared to be under this impression when he addressed the House of Commons in December 2010.

"When the consultation is launched, I will also publish a revised business case, a full appraisal of sustainability, noise contour maps and route visualisations, all of which can be completed now that the final preferred route for consultation has been determined."[7]

HS2 Ltd appears to have been unable to meet the Transport Secretary's expectations and only produced for the consultation the *Residential Airborne Noise Appraisal Maps* that are referred to in section 1 above. These are clearly not noise contour maps, a point that has been conceded by HS2 Ltd:

"Noise exposure contours have not been calculated for the proposed HS2 route, and have not been used to inform the noise exposure patterns or location of properties that comply with HS2 adopted noise criteria."[8]

Not only are the *Residential Airborne Noise Appraisal Maps* not what we were promised, but they fail to satisfy every one of the six criteria listed in section 3, above.

The explanation given by HS2 Ltd for not honouring the Transport Secretary's promise to Parliament is that "given the strategic nature of this stage of route design, it was not considered appropriate to publish noise contour maps due to the risk of misleading the public on noise levels at specific properties".[5] HS2 Ltd goes on the explain that "the noise maps that are incorporated into the AoS have been prepared to identify clusters of properties that could be affected by the proposal".

The Cubbington Action Group against HS2 does not understand this explanation. It seems that it is inappropriate to indicate the noise level at an individual property, but appropriate to indicate the noise level at a group of properties of which that individual may be a member. To do the former carries the "risk of misleading the public", apparently, whereas there is no such risk inherent in indicating to a resident that his/her property lies within a cluster of properties that would be subject to high noise levels.

Our confusion has been made the greater by the information on one of the two *Residential Airborne Noise Appraisal Maps* which cover Cubbington[9]. The handful of grey dots and single yellow dot marked on this map are clearly all assigned to individual properties. That this is the case is evident from the overlapping of grey dots where properties are close to each other.

There is also a putative anomaly when that map, which illustrates the noise impact without mitigation is compared with its paired map "including additional indicative mitigation"[10]. The latter map shows fewer grey dots and yet the section of track from which the noise will emanate is not marked as one of the "preliminary candidate areas for mitigation".

We presume that the noise impacts on Cubbington, with and without additional indicative mitigation, are different because the source noise reduction that is discussed

in section 7.3 below has been assumed for the "with additional mitigation" scenario, only; we would appreciate confirmation of this. We would also appreciate clarification of whether the effect of trackside noise barriers has been taken into account for any of the *Residential Airborne Noise Appraisal Maps*, the circumstances in which any such account has been taken, and the noise reduction that has been assumed. Accordingly, we suggest that:

HS2 Ltd clarifies the assumptions that have been made about mitigation in order to produce the *Residential Airborne Noise Appraisal Maps* in section 3.5 of Volume 2 of the AoS, including identifying the level of noise reduction that has been assumed.

In its explanation of why noise contours maps have not been published, HS2 Ltd also comments:

"… we have not performed detailed baseline noise surveys to verify our predictions of the existing background noise environment."[5]

It is interesting to note that HS2 Ltd appears to consider that a detailed knowledge of the "existing background noise environment" is necessary in order to construct noise contour maps. In the maps prepared by the ERDC for Heathrow Airport area, referred to above, only the incident noise from aircraft is plotted, with no consideration given to the background noise level due to other sources. However for other purposes, such as assessing the impact of road projects, noise difference contour plots are usually produced; these show the levels of noise change brought about by the new project.

It is assumed therefore that HS2 Ltd considers that noise difference contour plots would be appropriate for HS2, rather than simple noise contour maps. The AoS appears to recognise that the many currently tranquil areas through which HS2 will pass places an additional requirement upon design and mitigation and identifies "areas of high tranquillity, due in particular to rural isolation and low noise" as a "main sustainability challenge".[11]

We are promised that:

"A mitigation strategy that takes into account the relative importance of different factors affecting relative tranquillity … could help to reduce the potential impacts."[12]

If this means that HS2 Ltd is planning to produce noise difference contour plots showing HS2 noise levels relative to the background noise level, then we would support this approach as a useful step in developing a mitigation strategy that takes account of "the relative importance of different factors affecting relative tranquillity".

Obviously, a practical limit has to be agreed for the area to be covered by noise contour maps. For the AoS we are told that "a study area 3km either side of the proposed route has been used as it is considered sufficient to encompass all areas subject to potential HS2 residential airborne noise impacts"[13]. Subject to the geographic spread that the noise contour mapping study reveals, this appears to be a reasonable basis on which to proceed and should allow our Criterion 1 in section 3 above to be satisfied.

The contour spacing on noise contour maps should be chosen to satisfy our Criterion 2 in section 3 above

We suggest that:

Noise contour mapping be prepared and published as a matter of urgency for a study area 3km either side of the whole of the proposed route.

HS2 Ltd clarifies if noise contour mapping will present HS2 sound levels expressed relative to the background noise level.

5. Choice of Noise Metrics

5.1. Equivalent Continuous Sound Level

In the AoS a single sound metric has been employed to characterise the level of nuisance that will result from HS2 noise; this parameter is the "equivalent continuous sound level". HS2 Ltd defines this parameter as "the constant level of sound which, over a period of time, has the same total sound energy as the actual varying sound over the same time period"[14].

The time period chosen for the AoS is the eighteen hour period 06.00 – 24.00[15], with the level of sound expressed in decibels relative to the threshold of hearing after the application of an A-weighted filter. This parameter is usually indicated by the term $L_{Aeq,18hr}$ or just as L_{Aeq}.

We are told in the AoS that "the consensus of many worldwide studies, and consequently legislation, standards and guidance, is that annoyance correlates best with the measure equivalent continuous sound level L_{Aeq}"[16].

The use of $L_{Aeq,18hr}$ has been further justified by HS2 Ltd in the following terms:

"The LAeq is the standard and most proven single indicator for determining noise impact of transport schemes and was therefore appropriate for the appraisal of HS2."[14]

The AoS cites two examples of the use of $L_{Aeq,18hr}$ in "legislation, standards and guidance": the *Noise Insulation (Railways and Other Guided Transport Systems) Regulations 1996*[17], and DfT WebTAG guidance[18].

Whilst it is true that both of these domestic citations employ $L_{Aeq,18hr}$ to assess noise nuisance, the former is more than fifteen years old and the latter concedes that:

"… the current relationships are based on data gathered in past decades and further research is needed to assess the annoyance response to different sources of transport noise such as … high speed rail, which produces a significantly different spectrum of noise than conventional rail."[19]

We are concerned that the use of $L_{Aeq,18hr}$ as the noise metric will not "provide a good indication of the degree of noise nuisance" as required by our Criterion 3 in section 3 above.

An indication that policy on the use of the equivalent continuous sound level to indicate noise nuisance levels is evolving is given by the third example cited in the AoS of the use of $L_{Aeq,18hr}$ in "legislation, standards and guidance"; this citation is the *Environmental Noise (England) Regulations 2006*. These regulations, which implement the requirements of European Union Directive 2002/49/EC, relegate $L_{Aeq,18hr}$ to the status of a "supplementary indicator"[20]. Whilst Directive 2002/49/EC considers it "useful to allow Member States to use supplementary indicators in order to monitor or control special noise situations"[21], its clear aim is to promote the use of "harmonised indicators for the determination of noise levels"[22].

The EU Directive selects L_{den} as the common noise indicator "to assess annoyance"[21]; this is reflected in the *Environmental Noise (England) Regulations 2006*[23] and acknowledged by the AoS[24].

A rigid definition of the "day-evening-night level" L_{den} is provided in European Union Directive 2002/49/EC[25]. However, it may be loosely expressed as the equivalent continuous sound level calculated over the whole 24-hour day, but with a 5 dB weighting applied to sound recorded in the four evening hours and 10 dB weighting applied to sound recorded in the eight night hours. This weighting takes account of the increased nuisance caused by noise during the evening and night periods and the utilisation of L_{den} could, accordingly, be seen as a move towards satisfying our Criterion 4 in section 3 above.

The Cubbington Action Group against HS2 suggests that L_{den} is a more appropriate and meaningful indicator of noise nuisance level than $L_{Aeq,18hr}$ and cannot understand why HS2 Ltd would chose to use the latter rather than the former. This leads to the suggestion that:

Noise contour mapping employs the day-evening-night equivalent continuous sound level, L_{den}.

5.2. Considering Peak Noise

We are informed by the report that summarises the responses to the public consultation on HS2 that "799 respondents argue that using averages instead of peak or pass-by noise levels is inappropriate"[26].

This body of opinion appears to be supported by no less an authority than the World Health Organisation (WHO). Referring to the general form of the equivalent continuous sound level as $L_{Aeq,T}$, it expresses the view that:

"$L_{Aeq,T}$ should be used to measure continuing sounds such as road traffic noise, many types of industrial noises and noise from ventilation systems in buildings. When there are distinct events to the noise such as with aircraft or railway noise, measures of the individual events should be obtained (using, for example, L_{Amax} or SEL), in addition to $L_{Aeq,T}$ measurements."[27]

The case for employing a sound metric that relates to a single noise event, such as the peak sound level L_{Amax} or the sound exposure level (SEL), as an additional indicator in determining noise nuisance levels appears particularly strong when the characteristics of HS2 noise are considered. We have learnt from a response to a Freedom of Information Request that at any receptor point where $L_{Aeq,18hr}$ is recorded as 81 dB(A), then the equivalent pass-by noise level will be 95 dB $L_{Aeq,Tp}$[28]. So the "peak" noise level will be 14 dB(A) higher than a steady state signal having the same level as the equivalent continuous noise level.

The two models of one noise source having a steady level and another having a series of single noise events at 14 dB(A) above this level, are so dissimilar that it appears inconceivable that the former represents anywhere near an approximation of the noise nuisance impact of the latter.

Consider, for example, the application of the criterion of a "noticeable change" in noise level, which is one of the indicators of noise impact employed in the AoS. This document

advises that "in terms of a railway noise change, 3 dB L_{Aeq} or more is generally considered as a noticeable change"[29]. So if the ambient noise level at a receptor is X dB L_{Aeq} before the introduction of HS2 noise, then the introduction of HS2 noise having an equivalent continuous sound level of (X+3) dB L_{Aeq} would be regarded as just "noticeable" applying this criterion.

However, what an observer at that receptor location will experience is not a continuous sound level of (X+3) dB(A), but a series of single noise events of peak sound level (X+17) dB(A). Can this be regarded as "just noticeable"? This appears an unlikely assertion; according to the Institute of Acoustics and Institute of Environmental Management a noise level change of 10 dB or more has the significance of a "major impact"[30].

This situation is succinctly summed up by a "member of the public" respondent to the HS2 public consultation, quoted in the report that summarises the responses:

"I am concerned to see that the appraisal on noise has been made on average exposure. This is inadequate where noise is heard against a tranquil background - peak noise measures are more appropriate."[26]

It may be helpful to note that the Ministry of the Environment of the Government of Japan has chosen a peak sound measure to set noise standards for the Shinkansen Superexpress Railway[31]. It appears that not only are the Japanese in the vanguard of high speed railway technology, but they are also setting the pace in dealing with the noise impacts that result.

There appears to be a strong case for using either of the two parameters relating to a distinct noise event mentioned by the WHO in the above-cited reference as an additional metric for HS2 noise nuisance evaluations. This would be in conformity with the policy of EU Directive 2002/49/EC that allows supplementary indicators to be employed. Indeed, the Directive cites examples[32] where the use of supplementary indicators is appropriate and three of these ("quiet areas in open country", "the noise has an impulsive character" and "the low-frequency content of the noise is strong") are applicable to HS2.

Of the two parameters mentioned by the WHO, L_{Amax} and SEL, the former is probably to be preferred as it relates directly to the peak value of a single pass-by. SEL takes into account the duration of the pass-by also, which is very short for a high speed train and might lead to SEL understating the impact. SEL is also a less-easily understood concept for the general public.

It should be noted that neither L_{Amax} nor SEL is specifically included in the list of supplementary indicators in Schedule 3 of the *Environmental Noise (England) Regulations 2006*[20]. However, this omission should not prohibit the use of either of these two parameters in connection with the HS2 project.

All of the above leads us to suggest that:

Noise contour mapping is also produced using the noise metric L_{Amax} and this parameter is taken into account in any noise nuisance thresholds or limits that are set.

The Cubbington Action Group against HS2 believes that the appropriate combined use of L_{den} and L_{Amax} as noise metrics will be necessary in order to satisfy the requirements

of our Criterion 3 in section 3 above, and will make some contribution to satisfying our Criterion 4.

5.3. Night Noise

The topic of noise at night is not mentioned in either of the documents *High Speed Rail: Investing in Britain's Future Consultation Summary Report* or *Review of HS2 London to West Midlands Appraisal of Sustainability*.

We are told in the AoS that HS2 services "would operate 5am to midnight Monday to Saturday and 8am to midnight on Sunday, with maintenance and engineering activities undertaken at other times"[33]

This involves some operation at night, even if out of hours "maintenance and engineering activities" are ignored. There is, surprisingly, no universal definition of what the night hours are; it is probably appropriate in the UK to employ the period 23:00 – 07:00 hours[34] in accordance with the *Environmental Noise (England) Regulations 2006*. If that definition is employed, normal operations of HS2 will involve three night hours.

Directive 2002/49/EC specifies a second "harmonised indicator for the determination of noise levels" expressly to cover night noise, this being L_{night}[21].

Noise is particularly intrusive in the bedroom, and it is there that it has the most potential for harming health and well-being. In spite of this, the AoS makes no attempt to assess the impacts of noise from HS2 night-time operations quantitatively.

"For consistency with WebTAG and Noise Action Plans in England, the noise from the operation of HS2 has been appraised, for the purpose of the AoS, in terms of the equivalent continuous sound level L_{Aeq} for the 18hr period from 0600 to 2400. This approach is considered appropriate due to the predominantly daytime operation of HS2. Night-time noise has been qualitatively appraised in Section 8.2."[15]

Whether HS2 can be regarded as a service with "predominantly daytime operation" is arguable. Whilst it is true that HS2 will operate in every one of the twelve "day" hours, the three hours of operation at night (minimum) cannot be so easily discounted and are likely to predominate in the noise nuisance perception.

The AoS cites two more-particular reasons why the effects of night-time noise have been discounted. The first is that:

"It is likely that all the properties which would be identified as eligible for noise insulation under the night time noise insulation criteria within the Noise Insulation Regulations have already been identified in the AoS as being eligible under the daytime noise insulation criteria"[35]

That this statement is factually correct may be easily verified, and is not disputed. However, it ignores important advice published by the WHO, the *Night Guidelines for Europe*, which post-dates the Noise Insulation Regulations (but is not referenced anywhere in the AoS):

"… adverse health effects are observed at the level above 40 $dBL_{night,outside}$, such as self-reported sleep disturbance, environmental insomnia, and increased use of somnifacient drugs and sedatives. Therefore, 40 dB $L_{night,outside}$ is equivalent to the LOAEL [lowest observed adverse effect level] for night noise. Above 55 dB the cardiovascular effects

become the major public health concern, which are likely to be less dependent on the nature of the noise. Closer examination of the precise impact will be necessary in the range between 30 dB and 55 dB as much will depend on the detailed circumstances of each case."[36]

The parameter identified by the WHO as $L_{night,outside}$ is identical with L_{night} as defined in European Union Directive 2002/49/EC, and is, for practical purposes, interchangeable with the parameter L_{Aeq} (night-time) employed for the Noise Insulation Regulations, except that the former two are over an eight-hour period and the latter a six-hour period. Ignoring this inconsistency, it is plain that noise nuisance impacts at night are likely to arise at far lower levels than the night-time qualification level of the Noise Insulation Regulations (up to about 20 dB(A) lower, in fact).

So, we suggest, the first reason given in the AoS for discounting night-time noise impacts does not really hold water, as it misses the point that severe levels of night noise nuisance are likely to be encountered without qualifying for a noise insulation grant. This argument is even stronger for the second reason for discounting night-time noise that is given in the AoS:

"It is unlikely that any further candidate areas for mitigation would arise as a result of a night time noise assessment using a high maximum noise level (e.g. 85 dB L_{Amax})."[35]

No direct explanation of the derivation of the 85 dB(A) figure is provided in the AoS. Professor Waters has provided a logical explanation of the source of this figure[37]. He points us to a note to a table in PPG24, which says:

"Night-time noise levels (23.00 - 07.00): sites where individual noise events regularly exceed 82 dB L_{Amax} (S time weighting) several times in any hour should be treated as being in NEC C, regardless of the $L_{Aeq,8h}$ (except where the $L_{Aeq,8h}$ already puts the site in NEC D)."[38]

For this explanation to be correct, the 85 dB(A) figure has to be a façade measurement, adding 3 dB(A) to the 82 dB(A) specified in PPG24. Professor Waters comments:

"This should not conceivably be inferred to be an acceptable façade noise criterion of 85 dB $L_{Amax,S}$ and is not helpful in any way to assess the night time noise likely from HS2 operations. Leaving aside the fact that NEC considerations are not applicable to the assessment of new railway systems on existing dwellings, the adoption of 85 dB $L_{Amax,S}$ would be an extremely high noise level to use in this context."[39]

The Cubbington Action Group against HS2 agrees with Professor Waters. PPG24 Noise Exposure Category C, when employed for night noise, covers the range 59 dB $L_{Aeq,8hr}$ to 66 $L_{Aeq,8hr}$ and is the second highest noise category in PPG24. This band is 20 dB(A) or so above the level at which noise nuisance problems may be caused at night.

The Cubbington Action Group against HS2 expects that HS2 Ltd will heed the recommendations of such an eminent body as the WHO. In particular it hopes that HS2 Ltd will observe the guideline values recommended by the WHO, which are a "night noise guideline (NNG)" of 40 dB $L_{night,outside}$ and an "interim target (IT)" of 55 dB $L_{night,outside}$[40]. The IT is for use "in the situations where the achievement of NNG is not feasible in the short run for various reasons"[36]. We are also told that "all Member States are encouraged to gradually reduce the proportion of the population exposed to

levels over the IT within the context of meeting wider sustainable development objectives"[36].

The Highways Agency has acknowledged the WHO IT recommendation in a recent revision of the standard for noise and vibration assessment of road projects set out in its Design Manual for Roads and Bridges[41]. So a UK precedent to use the WHO guidelines has been set, and HS2 Ltd should look to follow this lead with a view to full NNG compliance.

This leads to the suggestions that:

Noise contour mapping is also produced using the noise metric L_{night} and this parameter is taken into account in any noise nuisance thresholds or limits that are set.

A policy for complying with the NNG, at least in the long term, is developed by HS2 Ltd and any reliance on IT as a stop-gap identified.

The Cubbington Action Group against HS2 also notes that the WHO reports that "short-term effects [of night-time noise on health and well-being] are mainly related to maximum levels per event inside the bedroom: $L_{Amax,inside}$[42]. In view of the considerable margin between HS2 peak value and equivalent continuous sound level that is noted in section 5.2 above, there would appear to be a risk that the sole use of $L_{night,outside}$ to assess night-time noise nuisance will underestimate the impacts on health and well-being. This fear leads to the further suggestion that:

A review is carried out of whether the sole use of the metric L_{night} will provide a reliable estimate of night-time noise nuisance and effects on sleepers to be made.

The Cubbington Action Group against HS2 believes that adherence to the WHO recommendations is essential if our Criterion 4 in section 3 above is to be achieved.

5.4. A-weighting

The application of A-weighting to sound measurements is a very widespread practice[43]. This is done to simulate the varying sensitivity of the human ear across the audio spectrum, and A-weighting is one of a family of characteristics (e.g. B-weighting, C-weighting) that may be employed.

The A-weighting characteristic first came into being in the 1930s, when it was adopted as a US standard following research carried out into the sensitivity of human hearing to single tones. Its use became widespread in the 1950s, when it was adopted by the International Standards Organisation (ISO) and was warmly embraced by acousticians, largely because it was simple to implement and employ. Since that time the use of A-weighting has become so widespread that it is possible that it is used as a matter of course, and without questioning its appropriateness to every application.

However, St Pierre and Maguire identify two important caveats that apply to the adoption of the A-weighting characteristic:

"First is that it is only representative of human ear response at low sound levels, mainly below 60 dB. Numerous studies have shown that the correlation between dBA measurements and loudness erodes as the sound pressure level is increased. Secondly, the contours were designed using single tones and therefore are mainly applicable to

single tone sounds. For example, random noise is generally perceived as louder than a single tone at the same sound pressure level, regardless of the weighting."[44]

These authors also warn that:

"The sharp rolloff at low frequencies minimizes their effect on the overall dBA reading, and in some instances, large low frequency tonal components can have no effect on the actual dBA measurement. Low frequency noise, however, has been established as an important factor in subjective assessment of loudness and annoyance. Kjellberg and Goldstein[45] showed that dBA measurements can underestimate loudness by as much as 14 dB when the noise primarily consists of low frequency components (below 400 Hz)."[44]

And:

"To summarize, there is a large amount of evidence that measuring A-weighted sound pressure level is not necessarily indicative of the loudness of noises. This is especially true when the noise is complex and/or composed of low frequency components."[44]

The WHO agrees that "A-weighting underestimates the sound pressure level of noise with low-frequency components"[46].

The AoS employs A-weighted sound metrics, but does not discuss these reported shortcomings. Neither is this topic mentioned in *High Speed Rail: Investing in Britain's Future Consultation Summary Report* or *Review of HS2 London to West Midlands Appraisal of Sustainability*.

The Cubbington Action Group against HS2 feels that there is a need to address this matter, since noise from high speed trains running at over 300 kph exhibits three characteristics that St Pierre and Maguire warn us about:

- Levels above 60 dB will be regularly encountered, whether measurements are made as peak levels or as equivalent continuous sound levels.
- The sound waveform will be complex, from the addition of mechanical and aerodynamic sources, far removed from single tone sounds.
- The sound will contain appreciable low-frequency components due to the contribution of aerodynamic noise[47]; a feature which has been confirmed by measurements[48]. This characteristic of the sound will be emphasised where absorptive noise barriers are employed for mitigation, as such barriers are less efficient attenuators at lower frequencies[49]. This effect was very apparent in the "boominess" of the train sound in the demonstration provided at HS2 roadshows.

In view of the doubt about whether A-weighted metrics will provide a good indication of the degree of noise nuisance that the noise will cause – an expectation expressed in our Criterion 3 in section 3 above – the following suggestion is made:

A review is carried out of whether the use of A-weighted metrics will provide a reliable assessment of noise nuisance to be made, and to determine if an adjustment should be applied to estimated sound levels.

The question of the suitability of using A-weighted metrics is not covered by either of the documents *High Speed Rail: Investing in Britain's Future Consultation Summary Report* or *Review of HS2 London to West Midlands Appraisal of Sustainability*.

5.5. Train Pass-by Rates

Since the equivalent continuous sound level will be calculated from a summation of the sound energy level from every train pass-by in the chosen time period, it depends not only on the sound levels involved but also on the total number of train pass-bys that take place in that time period and the length of those trains[50].

Regarding train lengths, we are told that:

"The basic unit for both types of train [GC gauge and classic compatible] would be 200 metres long and units would operate either singly or in pairs, giving a maximum length of 400 metres."[51]

A table of "two-way HS2 train movements" is provided in the AoS "for two scenarios; a scheme with High Speed Rail from London-West Midlands only (without 'Y') and a scheme which extends further north via Leeds and Manchester (with 'Y')"[52]. The train movement quantities given relate to "Operational Year 15".

We are told that "operational characteristics have been provided by HS2 Ltd including the number of trains and length of trains on each route segment …"[52], but the train length(s) upon which the tabulated data has been based is not advised. However, a note on a graph on the same page of the AoS confirms that it applies to "432 trains per day each 400 m in length"[53], so this seems a reasonable assumption that this also applies to the table.

This table reveals that on the track section south of Birmingham Interchange station for the "without 'Y'" scenario there will be a total of 432 train movements in the eighteen-hour recording period (06.00 – 24.00), at a peak rate of 28 per hour (i.e. 14 movements in each direction).

For the "with Y" scenario the equivalent figures are 576 total train movements, at a peak rate of 36 per hour (i.e. 18 movements in each direction). This represents about a 30% increase in total train movements in the eighteen hour recording period.

These figures imply a difference of about 1.25 dB(A) between the values of L_{Aeq} for the two scenarios ($10\log_{10}(576/432)$).

A further table included in the AoS "shows the estimated number of dwellings potentially impacted by operational noise from the London to West Midlands Proposed Route"[54]. These data relate to "without Y" traffic levels and the text in the accompanying paragraph implies, though does not explicitly confirm, that the *Residential Airborne Noise Appraisal Maps* presented in Volume 2 of the AoS were compiled using the same data.

The tabulated data identify the number of dwellings falling into each of three noise nuisance severity bands; these are the same bands used to determine the colours (grey, yellow or red) of the dots used to indicate locations affected by HS2 noise on the *Residential Airborne Noise Appraisal Maps*.

The AoS also includes an equivalent, though condensed, table showing the estimated number of dwellings affected by noise for the increased levels of traffic resulting from the operation of HS2 services extending to Manchester and Leeds (with Y)[55].

Comparison of these two tables indicates that the number of affected dwellings increases noticeably when the additional "Y" traffic becomes operational. For example, the estimated number of dwellings that will suffer a "noticeable noise increase", excluding the effects of "additional indicative mitigation", increases by about 40% (approximately 24,300 against approximately 33,600). So the *Residential Airborne Noise Appraisal Maps* only provide the picture for the initial London-West Midlands phase of HS2 and considerably underestimate the problem when HS2 has been extended to Manchester and Leeds.

Since it appears that the assumption has been made that all trains will be 400 metres long, any use of half-length trains will decrease equivalent continuous sound levels, leading to a corresponding decrease in the number of affected dwellings.

The report that summarises the responses to the public consultation on HS2 picks up on the topic of train pass-by rates:

"Some respondents emphasise that trains would be running at a very high frequency once the high speed rail network is operational and that this would exacerbate the noise impact on communities along the route."[26]

The response by HS2 Ltd to this sentence is:

"Another issue raised was with the number of trains used for the noise predictions. The AoS presented results for 14 trains in each direction during the peak hour of the day, which is the service frequency for the London to West Midlands scheme, but also presented results of a sensitivity study if the Y network was in operation (18 trains in each direction during the peak hours of the day). Candidate areas for mitigation were selected based on the assumption of the Y network being in operation in order to provide a provision for the possible extension of high speed services further north."[56]

This response appears to overlook the apparent failure of the *Residential Airborne Noise Appraisal Maps* to reflect the higher traffic levels of the Y network.

Media coverage of a speech made by the Technical Director of HS2 in March 2012 indicates that expansion of the London-West Midlands HS2 route to a capacity of 30 trains per hour in each direction might be possible in future[57]. Any such expansion, representing an almost 70% increase in traffic, would be expected to increase the number of dwellings affected by HS2 noise and the severity of the impact for all affected dwellings considerably. This prospect leads us to make the suggestion that:

A policy is developed by HS2 Ltd for "future proofing" any information provided on noise impacts on dwellings, in order to accommodate any foreseen changes in traffic levels.

Southdowns Environmental Consultants Ltd makes an interesting observation relating to the AoS estimation of the number of dwellings that will be affected by HS2 noise in the document submitted to the public consultation on HS2 by the 51m group of local authorities:

"The 33% difference in train movements between the 'with' and 'without' Y scenarios corresponds to a difference in average 18-hour daytime noise levels of 1.25 dB. It is evident therefore that relatively small changes of this magnitude can result in a significant increase in the numbers of properties affected, which provides evidence of

the sensitivity of noise impacts to small changes in noise input and calculation assumptions."[58]

6. Noise Thresholds and Limits

6.1. Colour Classification of Noise Nuisance

The AoS employs predicted values for the equivalent continuous sound level parameter over the eighteen hour period 06.00–24.00 ($L_{Aeq,18\ hr}$) to produce the estimates of the impact of HS2 noise on dwellings provided in the tables referred to in section 5.5 above and on the *Residential Airborne Noise Appraisal Maps*.

The lowest noise level that is considered a nuisance for the AoS estimates is nominally 50 dB L_{Aeq}. No upper noise limit is specified.

The lowest noise level is increased pro rata for locations where the existing background noise environment exceeds 47 dB L_{Aeq}. This adjustment is discussed further in section 6.2 below.

Two intermediate thresholds have been identified in the AoS, which split the range of sound levels considered into three bands. The lowest of the three is identified in the tables of dwellings affected by noise as "noticeable noise increase" and by grey dots on the *Residential Airborne Noise Appraisal Maps*. The middle range is identified as "noise insulation regulations" in the tables and coloured yellow on the maps. The top, unlimited, band is referred to as "high noise levels" in the tables and the dots on the maps are coloured red.

There is an inconsistency in the way that the lower limit and two intermediate thresholds are specified, which arises from the way that measurements are specified in the *Noise Insulation (Railways and Other Guided Transport Systems) Regulations 1996*[59]. This inconsistency is explained in the AoS, thus:

"All airborne noise levels calculated and reported are free field (see glossary for further explanation) with the exception of those used to represent noise insulation criteria. In this case, a facade correction of 3 dB has been used to convert free field noise levels to facade noise levels."[60]

This means that, for consistency with the other band limits, which are all expressed as free field measurements, the threshold delineating the bottom of the band designated as "Noise Insulation Regulations" (yellow dot) should be expressed as 65 dB L_{Aeq} (free field) and not 68 dB L_{Aeq} façade measurement. This leads us to suggest that:

All sound levels should be expressed as free field measurements.

The setting of noise thresholds and their use in assessing noise impacts, which is the subject of section 6 of this submission, is a topic that is not covered by either of the documents *High Speed Rail: Investing in Britain's Future Consultation Summary Report* or *Review of HS2 London to West Midlands Appraisal of Sustainability*.

6.2. Setting a Nuisance Threshold

Many of the areas through which HS2 would pass are unaffected by rail noise currently; in fact noise levels from all sources are generally low in such "tranquil" locations. We are told in the AoS that the background noise levels in areas "where predicted existing rail noise levels are low or there is no rail traffic" has been assumed to be 45 dB $L_{Aeq,18hr}$[61].

In its determination of a suitable lower noise nuisance threshold, the AoS considers what level of noise from HS2 would cause a "noticeable change" in noise, thus:

"In terms of a railway noise change, 3 dB L_{Aeq} or more is generally considered as a noticeable change. For the AoS study, this has been taken as the difference in railway noise, with and without the presence of HS2; this approach is consistent with the approach taken for HS1 (CTRL), Crossrail and WCML."[29]

So the level of HS2 noise which is just required to produce this "noticeable change" in a location where the existing background noise level is 45 dB $L_{Aeq,18hr}$ is 48 dB $L_{Aeq,18hr}$ (i.e. 45+3 dB).

The AoS also cites another source that it used in determining what the lower noise nuisance threshold should be – the WHO 1999 *Guidelines for Community Noise*. This document makes a recommendation for the noise level exposure for dwellings that:

"To protect the majority of people from being moderately annoyed during the daytime, the outdoor sound pressure level should not exceed 50 dB L_{Aeq}."[62]

However, the WHO also adds the rider:

"… most countries in Europe have adopted 40 dB L_{Aeq} as the maximum allowable level for new developments (Gottlob 1995[63]). Indeed, the lower value should be considered the maximum allowable sound pressure level for all new developments whenever feasible."[62]

Inexplicably, the AoS neglects to consider the advice of the Department for Transport on this issue; the Department's *Transport Analysis Guidance* (TAG) recommends that a level of transport related noise of 45 dB $L_{Aeq,18\ hr}$ "is used as the cut-off for both annoyance and valuation calculations"[64].

The AoS concludes that:

"… a Noticeable Noise Increase for HS2 AoS purposes is defined as having a total rail noise level of greater than or equal to 50 dB L_{Aeq} 06:00–24:00 with an increase in rail noise of at least 3 dB L_{Aeq} 06:00–24:00. At receiver locations where predicted existing rail noise levels are low or there is no rail traffic (assumed at 45 dB $L_{Aeq,18hr}$), a predicted HS2 noise level of 50 dB $L_{Aeq,18hr}$ or above would result in a Noticeable Noise Increase as per this definition."[61]

If our interpretation of this text is correct, it would appear to employ two different calculation methods depending on whether the background noise level before the introduction of HS2 is above or below 47 dB L_{Aeq}.

If the background noise level is above 47 dB L_{Aeq}, then our understanding is that the 50 dB L_{Aeq} threshold is increased by one decibel for every decibel that the background noise level exceeds 47 dB L_{Aeq}. We have no quarrel with this approach.

However, if the background noise level is below 47 dB L_{Aeq}, then the 50 dB L_{Aeq} threshold applies, irrespective of the background noise level. This means that "where predicted existing rail noise levels are low or there is no rail traffic" and, accordingly, the background noise level has been assumed to be 45 dB $L_{Aeq,18hr}$, the threshold will be set 5 dB above the background noise level.

This approach is open to the charge of being inequitable. It also appears to be inconsistent with the recognition elsewhere in the AoS that:

"A mitigation strategy that takes into account the relative importance of different factors affecting relative tranquillity … could help to reduce the potential impacts."[65]

It means that a dwelling in a tranquil area will have to suffer a noise increase due to HS2 of 5 dB $L_{Aeq,18hr}$ in order to be included in the totals of affected dwellings; according to the Institute of Acoustics and Institute of Environmental Management a noise level change of 5 dB has the significance of a "substantial impact"[30].

Our suggestions in this respect are:

A programme of field measurements of existing sound levels is carried out, in order to verify whether the background noise levels in areas "where predicted existing rail noise levels are low or there is no rail traffic" may be assumed as 45 dB $L_{Aeq,18hr}$.

A review is carried out to determine if the assumption of a minimum value for the nuisance threshold of 50 dB L_{Aeq} is appropriate.

6.3. High Noise Limits

A described in section 6.1 above, in addition to the noise nuisance threshold of 50 dB L_{Aeq} the AoS defines two higher noise thresholds that delimit two bands that identify dwellings that will be subjected to severe impacts from HS2 noise. The lower of these two bands is identified as "noise insulation regulations" and locations in this band are identified by yellow dots on the maps. The top, unlimited, band is referred to as "high noise levels" and the dots on the maps are coloured red.

The threshold that sets the lower limit of the yellow dot band is 65 dB L_{Aeq}, when expressed as a free-field measurement (refer to section 6.1 above). This threshold coincides with the level of newly-introduced noise at which a dwelling becomes eligible for a sound insulation grant under the terms of the *Noise Insulation (Railways and Other Guided Transport Systems) Regulations 1996* (68 dB L_{Aeq} façade measurement, which is equivalent to 65 dB L_{Aeq} as a free-field measurement).

The Regulations make further stipulations about the qualifications for sound insulation grants which are repeated in the AoS[66] and have, presumably, been taken into account in the calculation of the identification of affected dwellings.

The first of these stipulations is that the dwelling must be "not more than 300 metres from the nearest point of the nearest running rail"[67].

The second is that the noise introduced from the new source (e.g. HS2) is greater by at least 1 dB than the existing background noise level[68].

The third is that the noise introduced from the new source makes an effective contribution to the total noise of at least 1 dB[68].

The Cubbington Action Group against HS2 regards the noise nuisance level at which a dwelling is considered as eligible for a sound insulation grant as a significant indication of high noise nuisance, and agrees that its use as a threshold to identify dwellings that will be subjected to severe impacts from HS2 noise is appropriate.

The threshold at which the red dot (high noise levels) band starts is 73 dB L_{Aeq} and, as previously stated, there is no upper limit on the band. The source of this threshold is

identified as the Department for Environment, Food & Rural Affairs (Defra) Noise Action Planning requirements in a footnote in the AoS, thus:

"This criterion for railway noise exposure has been used in the past by Defra, to identify First Priority Locations for Noise Action Planning as part of The Environmental Noise (England) Regulations 2006."[69]

Whilst this is factually correct, the adoption of the Noise Action Plan threshold for HS2 ignores Defra's express instruction that:

"This threshold value should only be used for the purposes of identifying First Priority Locations for investigation in the context of this Noise Action Plan and should not be used for any other purpose or in any other policy context."[70]

Southdowns Environmental Consultants Ltd makes the following observation:

"The Noise Action Plans indicate that in due course relevant rail authorities will be asked to examine other Important Areas which do not contain First Priority Locations and where noise levels thus fall below 73 dB $L_{Aeq,18hr}$. The stated anticipated year of HS2 opening is 2026 and it is considered therefore that the focus of Noise Action Plans should have moved on by then, and that the focus will be on addressing the management of environmental noise at levels below HS2's threshold value for High Noise Levels, given that the Noise Action Plans are scheduled for review at least once every five years."[71]

The Cubbington Action Group against HS2 agrees with Southdowns that 73 dB $L_{Aeq,18hr}$ "represents an extreme and very high noise level for the assessment of noise impacts from new development outside existing dwellings"[72]. We feel that setting another noise nuisance threshold that is 8 dB higher than the level of eligibility for a sound insulation grant risks giving the impression that such high levels of noise nuisance are tolerable or acceptable; they are not.

Accordingly, we suggest that:

A review is carried out to determine if designating a "high noise level" (red dot) band is justifiable or appropriate.

6.4. Setting a Top Limit on Noise

As mentioned in section 5.2 above, the Ministry of the Environment of the Government of Japan has set limits on the noise exposure permitted for receptors affected by the Shinkansen Superexpress Railway. These limits are a maximum of 75 dB L_{pASmax} in commercial areas and 70 dB L_{pASmax} in residential areas, both of which, expressed as an equivalent continuous sound level, would be below the threshold for a sound insulation grant in the UK (assuming HS2 pass-by rates)[31].

A tabulation of railway noise regulations that are in force in European countries, assembled for the EU Commission, indicates that a number of these countries have limits of some sort in operation[73]. Those adopted by The Netherlands, Austria, Italy and Switzerland appear to be the most stringent and would apply to new projects, such as HS2. Belgium has limits in place for high-speed rail. The Czech Republic, Denmark, Finland, France, Germany, Hungary, Norway, Poland, Portugal and Sweden have some limitations in force, with varying degrees of prescription.

In the United Kingdom the regulatory approach is not to limit the noise nuisance caused by new railway lines, but to constrain planning permission in noise-affected locations and to require noise insulation grants to be made for newly-affected properties.

The Cubbington Action Group against HS2 feels that the current national UK approach does little to encourage developers of major transport schemes, such as HS2 Ltd, to expend resources on noise mitigation, particularly in situations where the number of dwellings affected is small. Put simply, it is often cheaper to make a few noise insulation grants than to build expensive noise abatement structures.

We wish to see some constraint applied to the maximum noise level that HS2 will inflict on any dwelling, in a similar form to that which operates in many other European countries. In the light of the nature of current UK legislation, it is likely that any such constraint would have to rely on the hybrid bill to give it the force of law. In such circumstances it would be equitable if relaxations in noise limits were allowed, if it proved to be technically impossible or economically not viable to achieve the necessary mitigation level. However, in such cases we would like to see recognition that high noise levels can render dwellings uninhabitable, for practical purposes, and that noise insulation of the property may not be an adequate remedy in such cases. Where this occurs we suggest that the option to purchase any affected property should always be considered as a suitable remedy.

In the light of this, we make the suggestion that:

Consideration is given to ways in which a maximum noise exposure limit could be applied to HS2.

6.5. Splitting the Grey Dot Band

A receptor classified in the AoS as exposed to a "noticeable noise increase" due to the introduction of HS2 noise, as indicated by a grey dot on the *Residential Airborne Noise Appraisal Maps*, may expect to experience noise somewhere in the range 50 dB L_{Aeq} to 65 dB L_{Aeq}. So if this receptor is in a location "where predicted existing rail noise levels are low or there is no rail traffic", and accordingly the existing noise level has been assumed to be 45 dB L_{Aeq}, the introduction of HS2 noise will result in a noise increase of between 5 dB(A) and 20 dB(A).

The relative degrees of the impact of a noise increase of 5 dB(A) and one of 20 dB(A) are manifestly totally different and it seems inconceivable that the AoS grey dot rating does not allow this distinction to be made. The owner of any property in the area marked by a grey dot will be concerned to know how bad things will be to a better precision that this. Southdowns Environmental Consultants Ltd has expressed the opinion that this lack of precision "represents a significant omission in the AoS approach to noise appraisal"[74]. The Cubbington Action Group against HS2 strongly agrees with this verdict, leading to the suggestion that:

The "noticeable noise increase" band used to identify dwellings affected by HS2 noise should be subdivided to improve the usefulness of the classification to property owners.

7. Calculation Methodology

7.1. Modelling Methodology

The AoS informs us that:

"The HS2 noise model has been developed using the CadnaA noise prediction software which involves modelling a three dimensional approximation of the study area and implements the railway noise calculation methodology (Calculation of Railway Noise 1995)."[75]

We are also told that Calculation of Railway Noise 1995 (CRN) is:

"… the official model for assessing eligibility for sound insulation under England and Wales Noise Insulation Regulations for Railways and the model typically used for the environmental impact assessment of railway projects."[76]

However, the AoS admits that:

"For very high speed rail, i.e. above 300km/h it is likely that CRN would need to be adapted to have sources at two or more heights above rail: for example rolling noise and the second for aerodynamic noise, however the research basis for this change in calculation methodology is not currently available."[77]

In connection with its use in the modelling employed for the roadshow sound simulations, another shortcoming of CRN has been advised. This is that it has no capability to model the frequency-dependent noise mitigation associated with absorptive trackside noise barriers.[78]

Despite these acknowledged shortcomings, the CRN was employed for both the AoS and the sound simulations and only minor modifications were made. In the case of the AoS:

"It was decided that some modification to the base CRN calculation should be included to account for aerodynamic noise. The best option at this stage was to retain a single noise source but alter the source height."[79]

And for the sound simulations:

"… the Dutch Standard for calculating railway noise, RMR96, which does predict the frequency-dependent noise mitigation, was used to calculate the relative levels of sound reduction between frequency bands for each demonstration."[78]

The AoS does not record whether RMR96 was employed in any of the calculations reported in its pages.

The defence by HS2 Ltd against responses to the public consultation that complained about its use of CRN for the AoS is that the intention was to provide "a strategic appraisal of airborne noise impacts on dwellings at a level of detail commensurate with the design of the project at this stage of development"[80]. On this basis HS2 Ltd puts up a characteristically robust defence of the use of the CRN:

"The noise model approximates values for noise impacts based on national standard methods for calculating railway noise, which are accepted and commonly used since publication in 1995 by UK experts in railway noise assessment."[80]

A more helpful explanation has been provided in a technical note:

"The exact source height is not generally important for the unobstructed propagation of noise from the railway but it becomes critical when determining the noise reduction afforded by noise barriers."[81]

We accept that, excluding the issue about the efficiency of noise barriers (which is considered in more detail in section 8 below), any inaccuracies that may have resulted from the use of the CRN for the noise propagation predictions in the AoS are probably within what is reasonable for "a strategic appraisal". However, we do not think that the approach that was taken for the AoS will be justifiable for the EIA.

This either requires that HS2 Ltd addresses the issue of the "research basis" necessary to modify the CRN for aerodynamic noise not being "currently available" or that an alternative calculation methodology to the CRN is adopted. On this latter point, there do seem to be proven alternatives in use in other countries (e.g. Schall 03 2006[82]).

Our suggestion is that:

A policy for achieving a robust and proven noise propagation model for the EIA, either by adapting the CRN or by employing an alternative model, is developed by HS2 Ltd.

There also appears to be some confusion about the precise nature of the "modification to the base CRN calculation … to account for aerodynamic noise" that was employed for the AoS. In that document we are told that:

"Following a review of 3m high barriers, the acoustic barrier effect, for these or higher barriers, expected from high speed rail at above 300km/h was simulated for modelling purposes by reducing the actual barrier height by 1m for calculation purposes only and retaining a source 1m above the head of the rail."[83]

However, in the technical note referred to earlier in this section we are told that "the noise modelling for the strategic appraisal of HS2 published in the AoS assumed" for a "train speed > 300km/h and 3m barriers, effective source 2m above head of the rail"[81].

Accordingly, we suggest that:

HS2 Ltd clarifies the adaption that was made to the basic CRN model to carry out the calculations for the AoS.

7.2. Design Speed Assumption

The EU Commission requires that:

"The environmental impact of the projects concerning the design of a line specially built for high-speed or on the occasion of line upgrading for high-speed shall take into account noise emission characteristics of the trains complying with the High-Speed Rolling TSI at their maximum allowed local speed."[84]

The phrase "at their maximum allowed local speed" appears, unfortunately, to be open to interpretation in the case of HS2, as it has not been defined by the EU Commission.

The public consultation was informed that HS2 will be:

"A line capable of up to 250 miles per hour [400 kph] but with a maximum train speed of 225 mph [360 kph] assumed at opening."[85]

There will of course be sections of the line where, for environmental, operational or engineering reasons, the line capability and operating speeds will be reduced below these maximums.

HS2 Ltd has interpreted the "maximum allowed local speed" as being the speed "assumed at opening" and we are informed that, for the calculation of train noise, "… where design speeds are over 360 km/h, a maximum of 360 km/h is used …"[86].

A graph of noise train speed provided in the AoS does not extend beyond 360 kph, but Southdowns Environmental Consultants Ltd has extrapolated this graph to determine that noise at 400 kph is approximately 3 dB higher than at 360 kph[87].

So although HS2 will be a railway that is designed to support 400 kph on unrestricted track sections, noise nuisance estimates and the design of noise mitigation for such track sections will relate to the initial operational speed of 360 kph. In an apparent attempt to justify this, we are told that "in the future, trains could reach 250 mph [400 kph] on the condition that there would be no unacceptable increase in noise levels".[51]

Since "no unacceptable increase" gives little assurance, the more robust promise giving at the time of the public consultation, that "speeds above 225 mph would not be allowed unless impacts of operation could be demonstrated to be no worse than currently assumed for operation at 225 mph"[88], is to be preferred (on the assumption that "impacts of operation" encompasses noise impacts)."

If this manipulation to save 3 dB on noise nuisance levels is to be acceptable, an effective guarantee is required that operational speeds will not be raised to the maximum unless it has been demonstrated that noise nuisance levels will not increase as a result. Any such demonstration should consider not only source noise levels but also any noise barrier efficiency reductions that may result from higher running speeds (refer to section 8 below).

To be effective any guarantee will be required to be enacted in Law, for example as a provision in the hybrid bill, and require confirmation by measurement.

Our suggestion in this respect is that:

Either noise calculations should be made at the maximum design speed of each track section or, failing that, at the initial operating speed. The latter option should only be exercised providing that a binding and irrevocable guarantee is given that any subsequent increase in operating speed will only be permitted when it can be demonstrated that it will not increase noise nuisance levels at any location.

7.3. Adjustments to Source Levels

The European Union technical specification for interoperability (TSI) relating to the 'rolling stock' sub-system of the trans-European high-speed rail system, which has been adopted as Commission Decision 2008/232/CE, stipulates a maximum train pass-by noise level of 92 dB $L_{pAeq,Tp}$ ±1 dB, measured at 25 metres when the train is travelling at 320 kph[89], which is the highest speed covered by the specification.

HS2 Ltd has assumed a train pass-by noise level of 95 dB $L_{pAeq,Tp}$ at 360 kph[28], which is broadly consistent with the above requirement of EU Decision 2008/232/CE.

However, EU Decision 2008/232/CE also permits that, for "new rolling stock to be ordered after 1 January 2010", a "reduction of … 3 dB(A) at speeds of 300km/h and 320km/h"[90] may be made to the maximum train pass-by noise level.

HS2 Ltd has applied the provisions of this paragraph by claiming "a 3 dB reduction in noise emissions at source based on the anticipated noise control improvements in the next generation of high speed rolling stock"[91]. Whilst EU Decision 2008/232/CE does not specify the pass-by noise limit or the level of the reduction that applies at 360 kph, the claimed 3 dB(A) appears to be entirely within the spirit of the meaning of the EU provision. HS2 Ltd has further defended its decision on the grounds that "further technology currently available in the industry indicates this is achievable"[92].

There are always dangers in using a "post-dated cheque", which is what the TSI noise control improvement allowance appears to be. This is aptly illustrated by referring to an earlier version of the rolling stock sub-system TSI, adopted in 2002 by EU Commission Decision 2002/735/EC. This earlier version also stipulates a maximum train pass-by noise level of 92 dB(A) ±1 dB, measured at 25 metres when the train is travelling at 320 kph[93]. It also permits a reduction of 3 dB(A) at speeds of 300 kph and 320 kph, but this applies to "rolling stock to be ordered after 1 January 2005"[94]. So in two specifications issued six years apart the date for applying the reduction appears to have slipped by five years.

The view on Southdowns Environmental Consultants Ltd on this matter is that:

"… there is no guarantee that the claimed reduction in TSI emission noise limits will be delivered. Indeed, the Noise Action Plans indicate that the limits for start-up, pass-by and stationary noise are not expected to change."[95]

Whilst the Cubbington Action Group against HS2 does not oppose the proposed source noise reduction in principle, it does feel that HS2 Ltd needs to provide evidence to support its claim that "further technology currently available in the industry indicates this is achievable". In this respect we note that HS2 Ltd has undertaken that "the train noise level will be revisited and checked for suitability as the input to the more detailed EIA"[92]; accordingly, we suggest that:

A review is carried out of the technical risk associated with claiming a 3 dB(A) reduction in train source noise for anticipated noise control improvements in the next generation of high speed rolling stock.

There is another matter associated with this claimed reduction in train noise source level that requires comment, arising from the proposed airborne noise mitigation hierarchy, which is "mitigation at the source, including the rolling stock and track, before mitigation of the propagation pathway, including barriers and earth bunds"[96]. Apparently in conformity with this strategy, the AoS treats the assumed reduction in train noise source level as "only valid for the proposed route with additional indicative mitigation"[97].

The view on Southdowns Environmental Consultants Ltd on this matter is that:

"If the emission limits were to be delivered, however, then it is not unreasonable to expect that the reduced noise levels should be built into the base engineering case from the outset."[95]

We agree and feel that the way in which this source noise reduction has been applied risks confusion about the level of mitigation that can be achieved by local measures, since the 3 dB(A) reduction will apply even to track sections where no physical barriers to reduce sound propagation have been employed. Accordingly, we suggest that:

The treatment of any assumed reduction in train source noise as contributing to the mitigation budget is reconsidered.

In order to "allow the assessment of rolling stock against pass-by noise limits", EU Decision 2008/232/CE sets out a specification for the condition of the track employed to assess whether a train meets the pass-by noise limits; a track which satisfies this specification is deemed to be a "reference track"[98].

EU Decision 2008/232/CE makes a distinction between "normal" tracks, which are those encountered in everyday situations, and a "reference" track which is maintained to a high standard to allow compliance with pass-by noise limits to be assessed.[98]

That this is an important distinction is confirmed by the following report on some measurements that were made on an SNCF TGV Réseau (TGV-R) high-speed train in France:

"It appeared that following track works at a few defined dates during the test campaign, some ballast dust might have been run over by the wheels, the roughness of which significantly increased on the following days. The measured noise values were then increased by 1.5 to 2.5 dB(A) after each track work episode, and the influence of the increase of the measured pass-by level can be noticed throughout the whole investigated speed range : 250 to 360 kph."[99]

The report shows that the cumulative effect of this track roughness degradation over several days of tests was in the range 3-4 dB(A).

There is no mention of the possible impact of track roughness on noise source level in the AoS, or in the *Review of HS2 London to West Midlands Appraisal of Sustainability*. It was however raised as an issue by at least one respondent to the public consultation, Southdowns Environmental Consultants Ltd:

"Noise levels obtained in accordance with the TSI track reference conditions may also be lower than the noise levels measured on the high speed network under everyday conditions and, as the TSI for the infrastructure sub-system of the trans-European highspeed rail system indicates, the actual track quality (rather than the reference track quality for rolling stock type tests) should be taken into account in any environmental noise impact study of high-speed projects."[100]

Southdowns makes a suggestion that we support:

"It should be apparent therefore that unless assurances are provided to ensure that the track will be constructed and maintained to the TSI reference track conditions, then an acoustic track quality correction will need to be derived and should be applied to calculated noise levels in accordance with the TSI infrastructure requirements as part of the future EIA of the scheme and any subsequent noise management procedure."[101]

Since we feel that it is probably not practical to maintain the HS2 track to TSI reference track conditions, then we make the suggestion that:

A review is carried out to determine if it is appropriate to apply a correction to increase the noise source level to account for track quality degradation during normal operation.

A satisfactory response by HS2 Ltd to the suggestions that we have made in sections 7.1 to 7.3 is necessary if our Criterion 5 in section 3 is to be satisfied.

8. Mitigation of the Noise Propagation Pathway

8.1. Mitigation Strategy

The AoS expresses the view that:

"To mitigate potential impacts in areas of high operating speeds, there is a need to control aerodynamic noise through advanced rolling stock design. Without first mitigating the source of aerodynamic noise, wayside noise barriers are not likely be as effective or feasible, due to the required increase in barrier height, to provide shielding to the entire train."[102]

Reducing the source noise level as a mitigation measure has the considerable advantage that, unlike noise barriers or bunds which have only a local effect, a source noise level reduction will benefit every metre of the full speed sections of the track. However, it would appear that source noise level mitigation is likely to have a limited impact on the noise nuisance levels at receptors. An extensive design programme carried out in Japan "to reduce the aerodynamic noise generated by a pantograph" produced a revised design that "lowered the noise level from the current low-noise pantograph by about 4 dB"[103]. Compare this with claim by HS2 Ltd that a 3 metre absorptive noise barrier "can produce up to 17 dB attenuation depending on the relative positions of source, barrier and receiver"[104].

8.2. Barrier Height

The AoS paragraph quoted in section 8.1 above also raises the issue of whether it will be necessary for barriers to shield the whole train, rather than just the wheel/track area, at HS2 maximum speeds. It concedes that there may be a need for an "increase in barrier height, to provide shielding to the entire train". However, the barrier specification in the AoS assumes that higher barriers will not be required:

"Noise reduction would be equivalent to that achieved by use of 3m high noise barriers (or bund) at all the preliminary candidate areas for mitigation or, at viaducts, by 2m high barriers; noise-absorbent materials would be used throughout."[91]

The AoS provides no justification that 3 metre noise barriers will be sufficient, other than the possibly optimistic assumption that mitigating the source of aerodynamic noise will render higher barriers unnecessary.

However, a search of the literature that has been cited in this submission reveals that others think that increased noise source height, and the resultant need to specify higher noise barriers, is an issue for very high speed trains such as HS2:

"In general, aerodynamic noise has lower peak frequencies than does wheel-rail noise, which means that a barrier is less effective at attenuating aerodynamic noise. In addition, aerodynamic noise sources tend to be located higher up on the train than wheel-rail noise sources. As a result, a noise barrier high enough to shield aerodynamic

noise will be relatively expensive compared to a barrier for controlling wheel-rail noise, since it must extend 15 feet or more above the top of rail. For operating speeds up to about 160 mph, a barrier high enough to shield wheel-rail and other lower car body sound sources would normally provide sufficient sound attenuation."[49]

"A relatively low barrier will not shield sound sources located high above the guideway, since such sources would protrude above the top of the barrier. This noise includes noise from propulsion sources, such as cooling fans, as well as aerodynamic noise generated at the upper part of the train."[105]

"The pantograph installed on a train roof is one of the major sources of aerodynamic noise in high speed trains"[103]

"The acoustic energy of aerodynamic noise is proportional to a train's speed by a power of 6 to 8, which is higher than for other kinds of noises such as rolling noise and structure-borne noise. Accordingly, as operational train speed increases, aerodynamic noise becomes the predominant source of high speed trackside noise. In the case of Shinkansen trains, aerodynamic noise becomes dominant when velocity exceeds approximately 200km/h."[103]

"The contribution of elevated sources to overall train noise levels is a key component in the determination of overall acoustic barrier performance, which is dependent on the geometric relationship between individual sources, receiver and the barrier apex. Significant reductions in sources of noise at low height such as wheel rail rolling noise will not therefore be reflected in the net reduction of overall train noise levels where the contribution of other higher sources to train passby noise levels is significant."[106]

"… it can be deduced that the reducing effect of sound insulation walls is significantly higher for freight trains compared to high speed ICE trains. This effect can essentially be put down to the reduced effect on high positioned noise sources as aerodynamically caused noises by the pantographs."[82]

8.3. SNCF Research on Train Noise Sources and Barrier Performance

Members of the Infrastructure and Engineering Department of SNCF (French Railways) have been engaged, over a number of years, on a programme of field measurement and computer modelling of high speed train noise sources and mitigation methods. This research has progressed to the stage where at least initial conclusions may be drawn.

To an extent, the SNCF researchers echo some of the comments that have been made by their peers in other countries:

"At higher running speeds, the energy of aerodynamic noise sources located on the roof of the train increases and the barrier height is not sufficient."[107]

And, commenting upon an observed decrease in noise barrier efficiency when the train speed increases:

"It is probably due to the increased contribution of aerodynamic noise with the train speed, especially around the pantograph and its cavity that are higher than the noise barrier."[108]

At the same time however, the researchers have found that "the transition speed between rolling noise and aerodynamic noise for the TGV Réseau is higher than often

previously claimed, when it had been said to lie around or under 300kph"[99]. This does not mean however that the contribution from aerodynamic noise at higher speeds may be ignored:

"… a significant reduction of the pass-by noise of a TGV train set running at commercial speed (≈320 kph) can only be reached by acting both on the aerodynamic sources and the rolling noise sources …"[109].

Evidence that the aerodynamic noise contribution is significant has been presented by the SNCF researchers both in tabular form and as a three-dimensional histogram. In the former, the pantograph is shown to be the highest level source at 350 kph[110] and in the latter it is the second largest source at that speed[111].

A particularly informative part of the SNCF research programme is the use of acoustic array measurements and computer source modelling to identify the locations of noise sources on the train, and noise maps have been produced which show the noise sources superimposed upon a profile drawing of the train, with intensity indicated by colour. These noise maps have been prepared for different third octave bands, in order to illustrate how the sources impact on different sections of the audio spectrum.

One of these noise maps clearly shows that the pantograph is the dominant noise source for the two third octave bands centred on at 250 Hz and 315 Hz even at 320 kph[112]. Another shows that the pantograph is amongst the noise hot spots at 360 kph, even when the broader band of 315 Hz to 4 kHz is considered[113].

A noise frequency spectrum plot for 320 kph, with wheel and track noise absorbers employed, confirms that pantograph noise makes a significant contribution, particularly in the 200 Hz to 300 Hz region[114].

The researchers' own summary of the noise sources that come into play as speed increases is:

"At 200 kph, the rolling noise is an important source but the noise radiated by the area located around the first bogie (bogie and windscreen) is of the same order,

"At 300 kph, the area around the first bogie is the main source but the noise radiated by the cooling and the pantograph can not be neglected,

"At 350 kph, the area located around the first bogie and the pantograph radiates much more."[115]

A graph of noise reduction achieved by a 3 metre high reflective barrier, providing 2.1 metre shielding above the rail head, has also been provided; this shows how the noise reduction varies with frequency[116]. In the region between 200 Hz and 400 Hz the barrier efficiency is markedly worse at 375 kph than at 320 kph, with the insertion loss of the barrier being little more than 1 dB at the higher speed.

This barrier characteristic is consistent with there being a significant noise contribution from the train pantograph at 375 kph; this noise, being emanated by a source higher than the noise barrier, is consequently being unaffected by it. If this hypothesis is correct, the effect should be more marked with an absorptive barrier, since such a barrier will be more effective at attenuating noise from sources lower down on the train while still being ineffective at reducing pantograph noise.

When barrier efficiency has been considered across the whole band, as is the case for tables of comparative efficiency for different noise barrier designs presented by the SNCF researchers[117], A-weighting has been applied. Since the use of this weighting characteristic applies a 10 dB reduction at 200 Hz, it probably results in undervaluing the effect of pantograph noise on the overall barrier performance (see the discussion in section 5.4 above).

8.4. The HS2 Ltd View on Barrier Performance

In its response to issues raised about the AoS by the public consultation, HS2 Ltd comments on the specific issue of the possible impact of pantograph noise on noise barrier performance:

"The issue of the assessment of noise from the train pantograph was also raised, in particular with reference to the height of the source compared with noise barriers. The pantograph is a consideration in the assessment of the noise impact and the AoS took this into account by making appropriate changes to the relative height of train source and barrier when considering mitigation. While noise from the pantograph does need to be considered, and will be reviewed at the time of the EIA, its significance is often overstated. The wheel-rail interface will remain the most significant part of the noise from the train, even at high speed."[118]

Whilst the undertaking to review this issue within the scope of the EIA is welcome and is clearly an essential activity, the last two sentences do rather give the impression that the writer of this paragraph, at least, has a far from open mind on this matter. It is hard to understand how such a dogmatic standpoint can be taken in the light of the evidence that has been present in sections 8.2 and 8.3 above.

Elsewhere Hs2 Ltd has conceded that this is, at least, an issue:

"As current high speed trains exceed 300km/h, aerodynamic noise around the bogie areas, at coach connections and around the pantographs (including where they connect to the train), increases. Because these sources are higher up the coach body, and therefore higher above the rails, a barrier will be less effective in reducing the noise from these sources than in reducing rolling noise."[81]

"An Environmental Impact Assessment of the scheme would be undertaken at the next stage if the scheme progresses. This would confirm the heights of noise barrier required at each location along the route and would help develop the design principles by which taller noise barriers could be provided without causing significant adverse effects in other environmental areas e.g. landscape and visual."[119]

The Cubbington Action Group against HS2 suggests that:

HS2 Ltd clarifies how it intends to establish whether aerodynamic noise sources higher up the train may be reduced sufficiently by design improvements or whether higher noise barriers will be required.

8.5. Evaluating Noise Barrier Design

Where trackside noise barriers are to be employed to mitigate noise nuisance, it is important that barrier quality is sufficient to maximise the benefits. The AoS confirms that "noise-absorbent materials would be used throughout"[91], so it appears that purely reflective barriers will not be employed anywhere. However, aside from the use of noise

absorptive materials, the indications are that barrier efficiency varies with the configuration employed. This has been demonstrated by the SNCF research referred to in section 8.3.above, with particular regard to the use of diffracting edges at the top of the barrier[120].

Many different types of commercial barrier are available, utilising an array of different materials. Some of these designs have the added advantage of being visually less intrusive in certain environments.

The AoS advises that only 2 metre high noise barriers will be utilised on viaducts[91]. Southdowns Environmental Consultants Ltd comments:

"It is not apparent from the AoS that the effects of elevated train noise sources and reduced barrier performance have been accounted for in the calculation of the acoustic benefits of 2m high barriers on viaducts."[121]

Since the ultimate aim is to operate HS2 trains at speeds up to 400 kph, it is important that barrier performance is assessed at this higher speed as well as the initial operating speed at up to 360 kph.

The Cubbington Action Group against HS2 feels that a programme of tests is required in order to evaluate the effectiveness of different barrier designs and heights at 360 kph and 400 kph, at least. This programme should include barriers intended for use at normal trackside and on elevated sections, such as viaducts. We therefore suggest that:

HS2 Ltd commissions tests to evaluate the effectiveness of different noise barrier designs and heights at 360 kph and 400 kph at least.

Where the track design requires cuttings to be excavated, these will also serve as noise mitigation features. In some locations "artificial cuttings" will be configured by constructing earth bunds at trackside to provide noise mitigation. It is not clear how the level of noise reduction that will be achieved by such features will be assessed, leading to the request that:

HS2 Ltd clarifies how the level of noise mitigation provided by cuttings and bunds will be assessed.

It is to be hoped that the effectiveness of as fitted noise mitigation measures will also be verified once trains begin to run on the HS2 track. It is suggested that the trial operation period would provide the opportunity to do this. There will also need to be a policy in place to rectify any noise mitigation that is found not to achieve the calculated performance.

Accordingly, the Cubbington Action Group against HS2 suggests that:

A policy is developed by HS2 Ltd for verifying mitigation measures and rectifying any installations that do not satisfy predicted performance.

The calculations using the modified CRN that were made for the AoS indicate that a 2.1 metre high absorptive barrier will provide 9.5 dB(A) of noise reduction and that this compares with 11.5 dB(A) at 320 kph measured during the SNCF tests[81]. These results have been extrapolated by HS2 Ltd to estimate 3 metre barrier performance, since no SNCF measurements are available for comparison; the noise reduction obtained using a 3 metre absorptive barrier is predicted by the modified CRN to be 10.1 dB(A)[81].

A description of the roadshow sound demonstration for Wendover characterises the HS2 route past the receptor location as "viaduct over A413, then embankment, a 200m green tunnel under Pound Street, followed by another embankment"[122]. The mitigation employed for this location is identified as "3m effective absorptive noise barrier"[123]. We are also informed that the "unmitigated HS2 train" noise level is estimated as 79 dB L_{pASmax} and that the "mitigated HS2 train" noise level is estimated to be 63 dB L_{pASmax}, implying that the assumed mitigation is 16 dB(A)[124].

As reported in section 8.1 above, we have been told elsewhere that a 3 metre absorptive noise barrier "can produce up to 17 dB attenuation depending on the relative positions of source, barrier and receiver"[104].

Although it does not appear to have been stated in any of the literature published by HS2 Ltd, we presume that the 16 dB(A), or perhaps 17 dB(A), that has been assumed for mitigation takes account not only of the absorption by the noise barrier, but also of any noise source mitigation that is achieved. However, the reference to 17 dB which is quoted above refers only to the mechanism of "barrier attenuation" as being responsible for this noise level reduction. There appears to be some confusion about just how the assumed mitigation level has been made up, dB by dB. Accordingly, we request that:

HS2 Ltd clarifies what assumptions have been made in estimating the level of noise mitigation that will be achieved, and what contribution to the overall total has been assumed from each mitigation mechanism.

A satisfactory response by HS2 Ltd to the suggestions that we have made in sections 8.4 and 8.5 is necessary if our Criterion 6 in section 3 is to be satisfied.

9. Communications, Standards, Review and Accountability

There has been a distinct failure to date by HS2 Ltd to engage with local communities on the topic of noise pollution from HS2. The only attempt to communicate so far, which fell short of allowing engagement in meaningful discussions, was the sound demonstrations provided at consultation roadshows. These demonstrations were obviously a very expensive exercise, using very sophisticated equipment, but signally failed to reassure the bulk of the residents visiting the roadshows. The reasons for this failure may include a lack of transparency about the methodology employed, a suspicion that the noise impacts were being downplayed, and absence of any comparison of the situation with and without additional mitigation.

It may be the opinion of HS2 Ltd and its advisors that the topic of noise is too complicated for amateurs to understand and should be left to the professionals. If this is the case, we hope that this submission will serve to illustrate that there are a number of representatives of the affected communities who have made the effort to educate themselves about the issues involved. We venture to claim that these representatives have reached the standard where, at the very least, they are able to appreciate the arguments and be capable of entering into discussions with HS2 Ltd on behalf of their communities.

Also there were at least two high-quality responses to the public consultation by professional acousticians, raising important noise issues that have either been ignored

by HS2 Ltd in its published review documents or treated in an extremely perfunctory way.

Noise has been discussed at technical seminars organised by HS2 Ltd, but these have been aimed at a general audience and have not provided the opportunity to review the topic in detail. We have been advised by HS2 Ltd that it is "currently considering a further seminar to assist people's understanding" and that we will be "informed of possible dates for such a seminar"[8]. A year later, we are still waiting for news of this seminar.

The Cubbington Action Group against HS2 feels that HS2 Ltd must improve its act on noise and that there is an urgent need for a mechanism to be established that will allow a meaningful and detailed dialogue on noise issues to take place with representatives of local communities. It is suggested that, as the bodies that are intended to be the contact point with local communities, the community forums are the obvious starting point for devising a suitable mechanism. However, in making this suggestion we accept that the detailed discussions on noise that are sought would not be appropriate business for normal meetings of the community forums. Accordingly, we feel that a specialist group should be set up across all of the community forums to discuss noise issues and report back its findings to the community forums, so that they will be able to confront local issues on noise nuisance in an informed way. So we suggest that:

A specialist group is set up to report to community forums on noise issues.

In section 6.4 above the situation on noise legislation in the United Kingdom was compared with more enlightened regimes in other parts of Europe and Japan. The UK appears to lag behind the approach taken in some other countries, in that it appears that no constraints will apply to the noise nuisance caused by HS2, with the only protection offered to those affected being sound insulation grants for properties.

This situation shames the United Kingdom Government. Legislation is badly needed to protect UK citizens from harm caused by excessive noise levels from high speed trains. The current regime, where the sponsoring government department, or its agent, is the sole arbiter of what is acceptable noise nuisance is insufficient assurance that the interests of UK citizens will be safeguarded. Providing grants to provide noise insulation of properties is no substitute for ensuring that high levels of noise nuisance do not occur in the first place.

The WHO clearly sees excessive levels of environmental noise as a potential threat to human rights:

"WHO defines health as a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity, and recognizes the enjoyment of the highest attainable standard of health as one of the fundamental rights of every human being. Environmental noise is a threat to public health, having negative impacts on human health and well-being."[125]

There is a clear duty on the UK Government to protect its citizens from threats to their "fundamental rights".

The Cubbington Action Group against HS2 suggests that:

Legislation that will apply to HS2 and future high speed train projects is introduced by HM Government to enforce a legal limit on noise nuisance levels.

As well as not being subject to any noise nuisance limits the designers of HS2 do not have to conform to externally applied standards for the assessment of noise nuisance. This is not the case for designers of road projects, where standards are prescribed by the *Design Manual for Roads and Bridges* which:

"… must be used forthwith on all road projects for the assessment of noise and vibration impacts associated with construction, improvements, operation and maintenance associated with motorways and trunk roads."[126]

It appears that HS2 Ltd will be left to develop its own standards for assessing noise nuisance; this would appear to be the ideal recipe for developing dispute and distrust with those likely to be affected by HS2 noise. There is, of course, a precedent in the work that was done on noise from HS1. However, there are a number of distinct differences between the nature of the noise nuisance from HS1 and HS2 that suggest that significant changes in noise assessment methodology are required for HS2. For example:

- The route of HS1 largely follows established road and railway transportation corridors, whereas significant sections of the proposed HS2 route will be in areas currently largely unaffected by transportation noise.
- HS1 was designed for a maximum speed of 300 kph, whereas HS2 is being designed to accommodate 400 kph. This design speed increase affects both peak and equivalent continuous sound levels, as well as reducing the effectiveness of noise barriers.
- The frequency of high speed train movements on HS1 is much lower than is proposed for HS2 (8 trains per hour in each direction for HS1 versus up to 18 trains per hour in each direction for HS2), and even higher train frequencies (up to thirty trains per hour in each direction) have been forecast by HS2 Ltd. This increased traffic affects the equivalent continuous sound level.

It is clearly most unsatisfactory for HS2 Ltd to develop the standards to be used to estimate and assess the noise nuisance caused by HS2; there is a clear conflict of interest involved. It does not appear that HS2 Ltd has really addressed this issue. The AoS advises of the "HS2 noise and vibration working group" and that its purpose is to provide "scrutiny and advice; direction on the application and relevance of emerging noise/vibration legislation/guidance; new research findings; and peer review of the appraisal method"[127]. We are also told that the working group included "external members"[128]. However, the three external members identified in the AoS are all shown as having affiliation to either HS2 Ltd or consultants contracted to HS2 Ltd. We are told in addition that a representative of Defra is "also acknowledged to be involved with the working group", but that he "did not attend working group meetings"[129].

On this evidence, it is difficult not to characterise the HS2 noise and vibration working group as a rather cosy and incestuous body, far removed from the standard of independent review and scrutiny that is required. This leads to the suggestion that:

HS2 Ltd should set up a new expert body to review and scrutinise the standards to be used to estimate and assess the noise nuisance caused by HS2. More than half of the membership of this body should be demonstrably independent from Government, HS2 Ltd and contractors to HS2 Ltd.

The situation regarding noise nuisance from HS2 is clear; HS2 Ltd finds itself in the unfortunate position of the potential polluter and owes a duty to its numerous potential "victims" who live close to the proposed route. Placed in this position, HS2 Ltd has the clear responsibility to support the aims of the Defra *Noise Policy Statement for England* (NPSE), which are stated to be:

"Through the effective management and control of environmental, neighbour and neighbourhood noise within the context of Government policy on sustainable development:

- avoid significant adverse impacts on health and quality of life;
- mitigate and minimise adverse impacts on health and quality of life; and
- where possible, contribute to the improvement of health and quality of life."[130]

10. References

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2 *Review of HS2 London to West Midlands Appraisal of Sustainability*, paragraph 7.2.1 on p. 26, HS2 Ltd (for Department for Transport), January 2012 (http://assets.dft.gov.uk/publications/hs2-review-of-appraisal-of-sustainability/hs2-review-of-aos.pdf).

3 *Ibid.*, paragraph 7.2.2 on p. 26.

4 *HS2 London to the West Midlands: Appraisal of Sustainability*, Main Report Volume 2, section 3.5, (4D) Offchurch to Kenilworth/Coventry Gap (without additional mitigation), HS2-BZT-00-DR-SU-003-27 on p. 118, and (4D-M) Offchurch to Kenilworth/Coventry Gap (with additional mitigation), HS2-BZT-00-DR-SU-003-28 on p. 119 (http://highspeedrail.dft.gov.uk/sites/highspeedrail.dft.gov.uk/files/hs2-aos-report02_0.pdf).

5 Review of Appraisal of Sustainability, *op. cit.*, paragraph 7.2.8 on p. 28.

6 *Noise Action Plan Contours for Heathrow Airport 2010*, ERCD REPORT 1107, Civil Aviation Authority (for Heathrow Airport Ltd), August 2011 (http://www.heathrowairport.com/static/Heathrow_Noise/Downloads/PDF/2010-noise-action-plan-contours_LHR.pdf).

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[8] HS2 Ltd response to Freedom of Information Request FOI10/167, dated 8 April 2011 (http://www.hs2.org.uk/assets/x/77794).

[9] Appraisal of Sustainability, Volume 2, *op. cit.*, section 3.5, (4D) Offchurch to Kenilworth/Coventry Gap (without additional mitigation), HS2-BZT-00-DR-SU-003-27 on p. 118.

[10] Appraisal of Sustainability, Volume 2, *op. cit.*, section 3.5, (4D-M) Offchurch to Kenilworth/Coventry Gap (with additional mitigation), HS2-BZT-00-DR-SU-003-28 on p. 119.

[11] *HS2 London to the West Midlands: Appraisal of Sustainability*, Main Report Volume 1, paragraph 7.7.5 on page 75 (http://webarchive.nationalarchives.gov.uk/20111005090740/http://highspeedrail.dft.gov.uk/sites/highspeedrail.dft.gov.uk/files/hs2-aos-report01_0.pdf).

[12] *HS2 London to the West Midlands: Appraisal of Sustainability*, Appendix 5, paragraph 8.5.1 on page 53 (http://webarchive.nationalarchives.gov.uk/20111005090740/http://highspeedrail.dft.gov.uk/sites/highspeedrail.dft.gov.uk/files/hs2-aos-appendix05.pdf).

[13] *Ibid.*, paragraph 5.2.1 on p. 43.

[14] Review of Appraisal of Sustainability, *op. cit.*, paragraph 7.2.7 on p. 27.

[15] Appraisal of Sustainability, Appendix 5, *op. cit.*, paragraph 1.5.1 on p. 40.

[16] Appraisal of Sustainability, Appendix 5, *op. cit.*, paragraph 1.2.1 on p. 39.

[17] *The Noise Insulation (Railways and Other Guided Transport Systems) Regulations 1996*, Department for Transport (http://www.legislation.gov.uk/uksi/1996/428/made/data.pdf)

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