

MINUTES OF ORAL EVIDENCE

taken before the

HIGH SPEED RAIL BILL COMMITTEE

on the

HIGH SPEED RAIL (WEST MIDLANDS – CREWE) BILL

Monday, 20 July 2020 (Afternoon)

Virtual proceeding

PRESENT:

Lord Hope of Craighead (Chair)

Lord Brabazon of Tara

Lord Goddard of Stockport

Lord Haselhurst

Lord Horam

Lord Liddle

Lord Snape

IN ATTENDANCE:

James Strachan QC, Counsel, Department for Transport

Jacqueline Lean, Counsel, Department for Transport

WITNESS:

Rupert Thornely-Taylor, Acoustics and Vibration Consultant

IN PUBLIC SESSION

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(At 2.31 p.m.)

1. THE CHAIR: Good afternoon everyone and welcome to the first ever virtual meeting of the House of Lords Select Committee on the High Speed Rail (West Midlands - Crewe) Bill. It is good to be back after a long interval that was unavoidable due to the Covid-19 lockdown. A lot of people have been working very hard behind the scenes to make it possible for us to resume our proceedings in this new way. I'm sure I speak for all members of the Committee when I say how grateful I am to them for what they have done. It was so important that we should be able to carry on our work without further delay.

2. As it is some time since we last met I'm going to take a moment to go over some points that I mentioned when I opened the proceedings on 16 March. I am Lord Hope of Craighead, the Chairman of the Select Committee. I've been a member of the House of Lords since 1996. Until 2013 I was sitting as a full-time judge, first as a Law Lord in the House of Lords when it was the court of last resort in the United Kingdom, and then when the Supreme Court came into existence as its Deputy President. Since my retirement in 2013 I have participated in the ordinary business of the House as a crossbencher.

3. In a moment I will give the other members of the Select Committee an opportunity to introduce themselves. As you will hear, they all have great experience in the work of this House. We have agreed that if I am unavoidably absent from any meeting Lord Haselhurst will take the Chair.

4. This virtual meeting is being broadcast, as all our future public meetings will be too. A full transcript of each meeting will be put on our website. It can be accessed by means of the parent website, which is called parliament.uk. Our website will also set out the programme for our meetings, which may have to be revised from time to time, and any other relevant information. Once again, petitioners and all members of the public are encouraged to make full use of that website.

5. I wish to stress that in our consideration of the petitions and the promoter's response to them this Committee will be guided by the principles of fairness and impartiality. We shall proceed as fast as we can but not in a way that would fail to give effect to those principles. We propose to sit between the following times: on Mondays

from 2.00 p.m. to 4.30 p.m., on Tuesdays and Wednesday from 10.30 a.m. to 1.00 p.m. and from 2.00 p.m. to 4.30 p.m. and on Thursdays from 10.30 a.m. to 1.00 p.m. But virtually working can be very tiring for all those who take part so we will need to spread our hearings out quite a bit between these times to allow for that. So we will not be sitting continuously within these times.

6. Some of you may be thinking of writing directly to members of the Committee. As I said last time, please do not do that. It is inappropriate as the Committee has to exercise a quasi-judicial function in these proceedings. This means that we can act only on the evidence and submissions put forward openly and transparently in our public hearings.

7. As this Committee must act impartially and quasi judicially I come now to the declaration of interests. Most members have already declared their interests but it would be helpful for us to do so again as it has been so long since we last met. As I said when I opened the proceedings in March, I have one indirect interest that I must declare. I am a member of the Scottish Wildlife Trust. It is a corporate member of the Royal Society of Wildlife Trusts and it has similar interests to those of the Staffordshire Wildlife Trust. I will now ask the other members of the Select Committee to introduce themselves and to declare any relevant interests they may have. First Lord Brabazon of Tara.

8. LORD BRABAZON OF TARA: Thank you, Lord Chair. I'm Lord Brabazon. Some of you may recall that I was on the original HS2 Committee and I have no interests to declare.

9. THE CHAIR: Lord Goddard of Stockport?

10. LORD GODDARD OF STOCKPORT: Good afternoon. I'm Lord Goddard of Stockport. I've no interests to declare.

11. THE CHAIR: Lord Haselhurst?

12. LORD HASELHURST: I was a member of the House of Commons for over 40 years, most of that time representing the rural constituency of Saffron Walden. My main parliamentary attainment I think was to be the Deputy Speaker of the House of

Commons for a period of 15 years. The only interest that I have, if it can be counted as such, is that my eldest son is a very close friend of the daughter of Mr Colin Smith, who I believe advises HS2. I have never met Mr Smith. I've never spoken or communicated in any way with Mr Smith.

13. THE CHAIR: Lord Horam?

14. LORD HORAM: I'm John Horam, Lord Horam. I have no interests to declare. I've been a member of the House of Lords for seven years since 2013. Before that, I was a member of the House of Commons, not quite as long as Lord Haselhurst, I think just over 30 years, but I was a Minister of Transport at one stage so I do know a little about transport but I have no interests to declare.

15. THE CHAIR: Lord Liddle?

16. LORD LIDDLE: Hello. I'm Roger Liddle, Lord Liddle. I became a member of the House of Lords in 2010, having worked as a senior advisor in the period of the Labour Government, which included three years at the European Commission. I have no direct interests to declare. I live in Cumbria. I'm a member of Cumbria Count Council and Pro-Chancellor of Lancaster University. And, together with being a member of the House of Lords, that means I'm a regular user of the West Coast Main Line but that is the only indirect interest I have to declare.

17. THE CHAIR: Lord Snape?

18. LORD SNAPE: My name is Peter Lord Snape. I was a member of the House of Commons from 1974 to 2001 and I've been a member of House of Lords since 2004. Although I did work on the railway in steam days, long-lost time, I have no direct or indirect interests to declare.

19. THE CHAIR: Thank you all very much. It may be helpful now if I were to set out how this session will work. Everyone participating in today's session is in on the Zoom call and we can all see each other. You may need to switch to gallery view to do that. My microphone will remain unmuted throughout. Others may control their own muting but please remember to unmute before speaking. You may receive a prompt on your screen inviting you to do that. As far as possible we will follow a pre-determined

order of speaking as set out in my brief, which has been shared with all participants. Unless anticipated in a brief you should wait to be called before speaking. If you wish to intervene at any point please physically raise your hand so that it can be seen on the screen. I will then call you to speak at an appropriate point. In order to allow for interventions, I will invite speakers to pause frequently. I will then either call someone to speak or invite the speaker to continue if no one has any questions to put.

20. There's one other matter that I should mention. The House of Lords is sitting in the Chamber today in public business in the course of which there may be votes. If by any chance a vote is called while we're still in this session I will adjourn it for a period of eight minutes so that members who wish to vote may do so.

21. Participants should now have the exhibit bundles open and available. For this session this is bundle P5. We will navigate the documents using the numbers in the bottom left corner of each page.

22. We shall now begin with the presentation on noise and vibration by Rupert Thornely-Taylor. Mr Strachan?

23. MR STRACHAN QC (DfT): Thank you very much, My Lord. If it pleases Your Lordship and Your Lordship's Committee I'd like to introduce Mr Thornely-Taylor, who's going to provide a presentation on sound, noise and vibration.

24. Mr Thornely-Taylor is a fellow of and was a founder member of the Institute of Acoustics and also a member of several other national and international professional noise bodies. He has specialised exclusively in the subjects of noise, vibration and acoustics for 56 years and he's been an independent consultant in these subjects for the past 52 years and he currently heads the Rupert Taylor Ltd consultancy practice. He was for 10 years a member of the Noise Advisory Council chaired by the Secretary of State for Environment and he was Chairman and Deputy Chairman of two of its working groups, and he was a member of the Scott Committee which drafted the basis of the noise section of the Control of Pollution Act of 1974. And he was a member of the external review group of the World Health Organization's environmental noise guidelines for the European region and in 2016 he was the recipient of the Rayleigh medal awarded by the Institute of Acoustics for outstanding contributions to acoustics. And he has excessive experience of the effects of noise and vibration from the

construction and operation of railways and he's carried out studies for the Jubilee line extension, Crossrail, Dublin Metro North, Thameslink 2000 and he's been an expert witness on construction noise at public enquiries into several major infrastructure developments, including Victoria station upgrade and Bank station capacity upgrade and he was the expert witness in the Select Committees in both Houses on the High Speed Rail (London - West Midlands) Bill Phase One and on the Channel Tunnel Rail Link Bill, the Crossrail Bill and the London Underground Jubilee Bill.

25. And, My Lord, I will hand over to him in a moment but I just wanted to indicate that I will certainly try and keep any interventions from myself to a bare minimum to allow him to make his presentation but I know that Mr Thornely-Taylor would, of course, be very happy to answer any questions from the Committee as and when they arise but he will also pause at certain points to ask if there are any questions during the course of his presentation, if that's convenient to the Committee. And so without any more ado from me, My Lord, I will hand over to Mr Thornely-Taylor with Your Lordship's permission

26. THE CHAIR: Thank you very much indeed. Yes, Mr Thornely-Taylor.

Evidence of Mr Thornely-Taylor

27. MR THORNELY-TAYLOR: Thank you, My Lord. My Lords, I'm going to give a presentation referring to the slides in the pack P5. Slide numbers, as has been said, are found in the bottom left-hand corner of each one. And I'm going to be talking about sound, noise and vibration and if we turn to slide 2, which is headed 'Outline of Presentation', I will explain what sound is, I will explain what vibration is and the ways in which both those things are generated and transmitted from source to receiver. I'll talk about human perception of sound and vibration. Then I'll go on to measurement scales and measurement indices and using those I'll explain how one does assessments and, in particular, I'll talk about the relationship between noise and vibration and human response to them. Next I'll move onto how noise and vibration and their effects can be reduced. And then I'll explain government policy regarding assessment and decision making. Finally I will explain HS2's application of government policy.

28. If we now move to slide number 3, that's P5(3), sound and vibration arises in several ways on a project of this kind. Clearly top of the list is sound of the operation of

the railway and vibration from the operation of the railway. There's also fixed plant associated with a railway, which potentially emits sound and vibration. Where we have tunnels sound and vibration arise in a different way, which I will explain. But then there are aspects of conventional construction site noise and the effects of constructing tunnels.

29. I'm now moving on to slide number 4, which is headed 'Basics: What Sound Is'. Sound is oscillation at very, very small magnitudes compared with atmospheric pressure. It's propagated by wave motion frequencies between 20 cycles per second – and the unit is called hertz, abbreviated Hz – and 20,000 cycles per second or 20 kilohertz. Sound decays with distance, partly because it spreads out or geometric spreading; it gets diluted over a larger surface area. But it's also reduced, and the technical word is 'attenuated', by soft ground surfaces and by intervening obstacles, such as noise barriers, for example. It's measured in terms of frequency-weighted decibel, which are called dB(A) – I will explain what the A means in a moment – and the purpose of the dB(A) index is to try to approximate the response of the human ear. The human ear has a very special frequency response. It's very insensitive to low-frequency sounds and slightly insensitive to very high-frequency sounds and if you just measured sound with a physical meter you wouldn't get a number which matched what people hear. So we have to give it a weighting so that the sound level meter behaves more like a human ear than just a simple physical measurement device.

30. A noise is a sound which is unwanted. That's the conventional description of it. And it's quite difficult to measure noise from the point of view of sound that's perceived and unwanted by humans because of the complexity of the human ear and the person whose ear it is.

31. So I'll move –

32. THE CHAIR: Can I ask, beg your pardon, a question before you leave that slide? Is wind a factor in the spreading of sound? In other words, if you're downwind of the sound do you hear it more clearly than if you're upwind?

33. MR THORNELLY-TAYLOR: Indeed you do, My Lord. Wind is an important consideration when predicting environmental sound. It has the effect, actually, of curving the path that sound takes because wind doesn't have a constant amplitude as

you rise in height. It tends to get faster as you go up from the ground, which tends to curve sound downwards. So if you're downwind you get less of an effect due to noise barriers or the ground surface. And, conversely, if you're upwind in some circumstances the ground itself can behave as a noise barrier because the curved sound meets the ground surface and then bends up again. And the convention in doing environmental assessment noise predictions is to take a light wind from source to receiver as the basic prediction condition and that means it tends to be a rather pessimistic result and on many, many days the predicted sounds are actually less because the wind is either not there or in the opposite direction.

34. THE CHAIR: Thank you.

35. MR THORNELY-TAYLOR: I'll move to slide 5, P5(5), headed, 'Basics: What Vibration Is'. And vibration is the oscillation of solids, which can be propagated through wave motion. It decays with distance, as does sound, but in a much more complex way. It's attenuated by energy absorption in the soil and by obstacles and discontinuities in the soil. It's mainly of interest – that is vibration – it's mainly of interest in the range from half a cycle per second, half a hertz, to 250 hertz and it can give rise to audible sound, which is then measured in decibels, just as airborne sound is. And, as is the case with sound, human response to vibration is much more complex than can be measured with a meter.

36. Now the next slide, slide 6, the one with the coloured bar chart on the right, gives us some indication of what this dB scale that I mentioned amounts to in terms of perception. The decibel scale is a measure of proportional changes. That's the important thing. It's not like a temperature scale or a scale of weight or length, which measure absolute quantities. The decibel scale always tells you about changes in proportions. And there are some fundamental things to bear in mind, easy to remember and very helpful in understanding the difference between numbers one sees in predictions and measurements.

37. Broadly speaking, every time a level in dB goes up by 10 units you perceive it as about a doubling of subjective loudness. And that's true all the way up the scale, whether it's from something very, very quiet, from 20 to 30, or from something very noisy, from 90 to 100. There are slight changes as you go up the scale but that rule

holds very well. Conversely, every 10 decibel decrease is about a halving of subjective loudness. Then we move on to much more subtle changes. A 1 dB change – if I were to play a test sound – if we were sitting in a committee room in Parliament and I were to play a test sound and I instantaneously changed its level by 1 dB you would just perceive there'd been a change. Any less than that and you wouldn't notice anything had happened. If you went out of the room in between those two levels, if it was, say, 60 dB in the room, you went out of the room and came back and it was 59 dB or 61 dB, you wouldn't know there'd been any change. To know there's a change when there's a break between the two sounds in that way there'd need to be at least a 3 dB change. And this is talking about the actual instantaneous sound level; dB are also used for more complex indices I'm about to explain and we need to look at the effect of changes in those in a slightly different way. But, as far as the instantaneous sound level is concerned, those are the fundamental rules: 10 dB change doubling of loudness; difficult to know there's been a change in loudness if there's a break between the two events if the change is less than 3 dB.

38. On the right of the scale is what is sometimes called a noise thermometer. These are always a bit difficult because, for example, aircraft at a height of 200 metres, it depends what kind of aircraft it is, but it gives you a pretty good feel for what sound levels amount to. Hypothetically, if you had a university laboratory, a research laboratory, with an absolutely enormous amount of sound insulation and sound absorption somebody with absolutely perfect hearing might just hear down to nearly 0 dB but that's an absolute extreme. In ordinary life if you're in a room that you consider is pretty much silent and you can't hear anything it may well have a sound level around about 20 dB. And actually here we're talking about dB(A) because, as I explained a short while ago, the frequency response of the human ear is very different from that of a plain physical meter and we apply what is called the A weighting to make the sound level meter behave a bit like a human ear – be insensitive to rumbles and also a little bit insensitive to very high hisses. So at 30 dB(A) it's still very quiet; concert hall background noise it says on this noise thermometer, or country area at night with no local traffic. Then we move up the scale a bit. Actually open-plan offices these days aren't probably at 50 dB(A) because everybody's just tapping away at a screen not using telephones and things. But we move up a little bit: a normal voice at 1 metre about 60 dB(A), 30 metres from a petrol lawnmower, loud voice at 1 metre about 70 dB(A) and

then various machinery noise sources. Well over 100 dB(A) in a nightclub, if you're unlucky enough to be there, and underneath an aircraft taking off 1 kilometre from a runway you could be up to the 110 dB(A) area. That gives a flavour as to what the numbers actually mean in practice.

39. I'll move now in a minute to slide 7 but, as I'm moving from basics to a slightly more complicated subject, I'll pause for moment in case there are any other questions.

40. THE CHAIR: Yes. Lord Horam?

41. LORD HORAM: Presumably these dB(A) levels vary from person to person, depending on the quality of their hearing.

42. MR THORNELY-TAYLOR: They most certainly do and later on in the presentation I'll be showing how one gets a statistical distribution of people's responses to sound and that's partly because their hearing sensitivity varies and even people in good health without hearing damage have variable hearing sensitivities. But, as we can also see, their psychological response to sound also varies a lot and we must always keep that in mind.

43. May I move onto slide number 7? This one is headed 'LAmax Sound'. I've been talking about instantaneous sound levels but, of course, all those sources I was talking about, at least the ones towards the upper end of the noise thermometer, vary in level. Vehicles pass, reach maximum and pass away, sound level rises and falls. And nearly everything you hear in the environment, whether it's vehicles on the road, aircraft in the air, people talking, birds singing, the sound level never stays constant, with a few exceptions. If you're quite close to one of the major motorways we have, dual and three-lane carriageways, you may find that noise from traffic on a motorway is almost continuous; hardly any change in level. That's the broad exception.

44. So, given that sound has highs and lows, we sometimes are interested to know what the high levels are, the maximum level, and we have an index called Lmax for fairly obvious reasons. It has the 'A' in front of it because it has this A weighting that I've described to make the sound level meter sound more like a human ear and it gives us the LAmax index. In the days when sound level meters were first designed, they were analogue electronic devices with analogue electronic circuits in them and they

were devised so you could switch it either to respond very quickly to a fast-changing sound level or if that meant the needle on the dial went too fast to write any numbers down you could slow it down a bit and have a slower response. And even modern digital sound level meters still mimic the old analogue sound level meters and have those two settings. They no longer, as a rule, have needles on dials the way they used to, they'll give you a digital readout, but you can switch it to F for fast and the level will change as rapidly as the sound loudness changes or you can smooth it out a bit and use S for slow. And that gives rise to the insertion of the capital letter F, if it's fast, in front of max to give us the LAFmax index. In terms of the environmental assessment for HS2 for airborne sound wherever we have Lmax levels they are LAF, for fast, max and they more or less follow the rate at which the human ear responds to changes in loudness.

45. I'm going to move onto slide 8 which is headed the mouthful 'LpAeqT Measurement'. It's not quite as bad as it looks. It's obvious that while the maximum sound level of an individual event, like a motorcycle going by, can be very important, particularly if it's at night and it might awaken you, it's also important to know how often that sort of annoying event might occur because if you were in an environment where there was just one or two noise events in a period you wouldn't be nearly as annoyed as if they happened every few seconds or minutes. And we need some way of taking account of two different environments; one where there's an event at very rare intervals or another environment where there are very frequent events at maybe not such a high level. And we've got to be able to construct an index that will measure the annoyance value of the number of times the events happen and the actual loudness of them. And for that purpose we have an index called equivalent continuous sound level, which in its simplest way of writing is just Leq. We put various other letters in there to add to its complexity. We put a capital T where we might put 16 hour for time period, T for time, or perhaps eight hour for the night period. And in some standards documents you will see a little p in front, which just signifies that the L is basically measuring sound pressure, although after a lot of manipulation. And you'll see them in the environmental statement, particularly in volume 5, which is the part of the ES that contains, you'll see in a minute, highly complex tables and maps of the environmental noise effect of HS2. And they are plotted as contours for the two time periods 07.00 to 23.00 and the night period 23.00 to 07.00.

46. I'll move on to slide 9 before I pause to answer questions on this topic. The important thing is that Leq, it's not – people frequently refer to it pejoratively as an average and they say, 'Leq levels don't represent what people hear. They don't hear averages'. But it's not actually an average of sound levels. It's an index and the important thing is that the way it's calculated gives very strong weightings to the high noise events that occur during a period. It's not the same number that you'd get if you wrote down the sound level every minute throughout the day and average all those numbers. If there were one or two noisy events during the day and you calculated the LAeq for that period you'd get a much higher answer, a numerically greater answer, than you would if you did that sort of averaging. And in forums of all kinds, in tribunals of all kinds, where noise is an issue it's often mistakenly said, 'Oh, Leq is an average. It's an unfair way of representing the sound'. But that's not the case.

47. It is an index but because it includes sound levels measured in decibels it's also expressed in decibels and it follows basically the same rules, although in a slightly more complex way. Decibel scale, as I said, once again, is a measure of proportional changes, not absolute levels. And whereas when I was talking earlier about the basic dB(A) scale I talked about how things sounded in terms of loudness, because the LAeq scale also takes into account the number of events and the duration of the events some similar rules apply. And the first one is that if you double the energy in the sound or you double the number of sources, which is the same thing, or you double the duration of the sound event or double the number of similar events, the consequence of doing that is always a 3 dB increase in LAeq. Now you heard me say earlier that a 3 dB change was the smallest that you could hear in terms of loudness changes if you went out of the room and came back in again but we have to bear in mind with LAeq, while you might get a 3 dB change because everything you're measuring has got a little bit louder, it could also be because things didn't get any louder but they happened twice as often. And people's response to that isn't necessarily quite the same as a change in loudness, which I'll come back to in a minute. And the second rule of thumb is just the same as with doubling, meaning 3 dB change, 10 times the energy always gives you a 10 dB change and, once again, that could be 10 times the number of sources, 10 times the duration of an event or 10 times the number of similar events.

48. Well, I realise I have said a lot about a complex subject and so at slide 9 I'll pause

again to see if there are any questions before I move on.

49. THE CHAIR: Lord Haselhurst and then I'll come to Lord Liddle. Lord Haselhurst first.

50. LORD HASELHURST: Thank you, Chair. You sometimes come across people who live in a particular area or circumstances and you say to them, 'I really don't know how you can cope with the noise', that may come from any particular source. And people who say, 'Oh, it never bothers me. I've been living here sufficiently long I don't hear it in the same way you're hearing it'. And I can just remember a time when I was only, I think, 10 years old and going to stay with some friends in the village of Shap in Cumbria, which was then by the side of the –

51. THE CHAIR: Lord Haselhurst, you've gone mute again, I'm afraid.

52. LORD HASELHURST: Sorry about that. I once experienced staying in a house very close to a heavily trafficked A6 in the village of Shap and at first when I went to bed I thought, 'I'll never sleep with this'. By the end of the week I was not noticing. Is this a factor that plays a part and can it be measured?

53. MR THORNELY-TAYLOR: Yes, it is and it can be measured. I know Shap well and probably the basic sound level you were hearing varied only by a small amount and may not have had particularly prominent characteristics. And if somebody doesn't have an emotional feeling about a noise, and that's quite important, they do become accustomed to the background ground in which they're working or resting or sleeping. It can become different if there are special characteristics in the noise. If a large string of motorcyclists went by or there's a continuous repeated noise of people travelling to some event you might think you disapprove of you would react more strongly than if it were just a characterless continuous sound from private cars and lorries on a motorway. But you are right and I'll be showing in a minute the results of studying the way people's responses to noise vary. There can be people who have very little annoyance to moderately high sound levels. And, of course, it's also true that the opposite applies; there can be people very highly annoyed by extremely low sound levels.

54. THE CHAIR: Lord Liddle?

55. LORD LIDDLE: My question is on a similar theme. The kind of noise that annoys me is either very persistent loud noise or what stops you sleeping is a regular noise like a dripping tap or too loud a clock ticking or something that is regular I find very irritating indeed. I was brought up next to a railway marshalling yard in Carlisle and the noise of the wagons, as through the night the freight trains were reassembled, of the banging of the trucks and the ricocheting of the wagons, they never bothered me at all. And I think that was because, while it was quite loud, it was irregular and just something I got used to. Now is this something that you can generalise about with humans or are all humans different?

56. MR THORNELY-TAYLOR: All humans are different, although the differences tend to be scattered about a distribution curve, which I'm about to illustrate. But I think the most important thing is you probably didn't have the psychological reaction that the noise going on in the marshalling yard shouldn't be happening. 'Those so-and-sos shouldn't be doing that. That noise shouldn't be allowed'. You probably recognised that it was a necessary activity, unavoidable and was essential to the carrying on of a proper freight service on the railway and you, therefore, didn't have an emotional dimension to your response to the physical level of the sound. And that is very important. It's quite difficult to quantify it in numerical terms but when big noise cases come to trial in tribunals of one sort or another this sort of thing becomes very evident and it's quite difficult for the tribunal to resolve.

57. LORD LIDDLE: Yes. Thank you.

58. THE CHAIR: Can I put a question to you about the word 'energy'? We talk about sound levels and then we move to the amount of energy. Is energy the factor that produces the sound and how do you measure it?

59. MR THORNELY-TAYLOR: Energy is the factor that produces the sound and, in fact, we could measure sound levels in watts. The reason we don't is because the range of levels that you would get if you measured it in an absolute linear scale like that would be unmanageably large because each time the sound level goes up by 10 units the amount of energy in terms of watts, or watts per square metre if it's sound intensity, increases tenfold. And if you think about that noise thermometer I showed a few slides back going from green to red, if you went up from the bottom sort of 0, 10, 20, each

time you move up 10, 20, 30, 40 you're going up tenfold and you would end up writing down a sound level at the top of that scale in watts with a whole string of noughts after it and at the bottom of the scale you'd be in single figures. And that was why the decibel scale was invented; partly to compress that huge range and partly to take account of a general law which applies to all human perception, that we do respond to proportional changes much more than we do to absolute levels. And many things – if you pick up a weight and somebody places another weight in your other hand your judgment of comparative weights is much more in terms of how much one is heavier than the other rather than its absolute weight. Whatever the stimulus is, we tend to respond in terms of proportional changes. So the dB scale is there for that reason but it's fundamentally telling us what the energy is in terms of watts.

60. THE CHAIR: Thank you very much.

61. MR THORNELY-TAYLOR: It's joules if it's over time but it's energy per second in terms of watts.

62. THE CHAIR: Good. I think you can move on. Thank you very much indeed.

63. MR THORNELY-TAYLOR: Thank you, My Lord. To talk a bit more about the subject we've just been discussing, the first bullet point, the hollow bullet point on slide 10, is that sound levels on their own mean nothing. We could have the most superbly accurate sound level meter and it measures sound in terms of watts per square metre or decibels or other physical unit but it tells us nothing unless we're interested in its effect on a structure. For example, when space travel first came into being there was a lot of interest in the effect of very high sound levels in rockets on the structure of the rocket, and that's nothing to do with humans. But most of the time we're concerned with the effect of sound on humans and the only way we can link measured sound levels with human response is through social surveys. We've already talked how people's reactions to sound vary very widely. Some people take no notice of what others might think was a lot of sound and at the opposite end of the extreme, people may be highly annoyed by really quite low levels of sound. So the way to resolve that is to go out with a lot of clipboards and, at the same time, do environmental sound measurements, get responses to the social survey in terms of the percentage of the population that has particular responses, like annoyance or sleep disturbance or other responses which you can

discover through a questionnaire, and then to process all that and get a correlation between the sound levels using the index that takes account of both noisiness and number of events and the human response as measured by social survey. It will give you a correlation but it will have a lot of uncertainty associated with it. You always need to look at it in terms of the 95% confidence band, which is quite often wide. There is certainly never a clear distinction between an acceptable sound level and an unacceptable one or a significant or not significant. There's no cliff edge. And the same is true of vibration.

64. Now in slide P5(11), the next one, I am going to show you a graphical representation of what I've been just describing. And this curve, which is sometimes loosely referred to as a bell curve, is a plot of something called Gaussian distribution in statistics. It pops up in many contexts. It's not unique to sound by any means. And I'll explain what it's actually showing us. If the scale up the left is the percentage of the population and the scale moving from left to right is the degree of annoyance and we consider a particular sound environment, such as the noise level in Shap, we will find that the largest number of people will fall towards to the middle of the range, and let's say that 60% of the population say, 'I'm slightly annoyed by that noise', and that is the peak of this bell curve as I say, then we'll talk to some more people and we'll find a small proportion of them say, 'I got used to that noise a long time ago. It doesn't bother me really at all'. And those people will be plotted on this chart to the left-hand side, low degree of annoyance, even though we're still talking about the same level of sound.

65. And then you go and knock on somebody else's door and say, 'I want to ask you what you think of this noise', and they may say, 'I find it dreadful every day and it drives me up the wall. I can't sleep'. Still we're talking about the same level of noise, using our noise index, but we've found some people that we plot on the right-hand side of this chart, slide 11, and they've got a high degree of annoyance still at the same physical noise level. And it applies in all cases. You may read in environmental statements and see predicted sound levels and think that it's all cut and dried but, even if for physical reasons there is minimal uncertainty in the number that's been predicted, you still have to bear in mind that some people will be very highly annoyed by what looks like a moderate number; others will take no notice of it whatsoever. But the bulk of the population will fall in the middle and have the most frequently found response,

which, as I say, will probably be about 60% of the population fall in the middle. But always bear in mind the bell curve when interpreting environmental sound levels.

66. Now I've got a brief slide number 12 on measurement and then I'll be going on to government policies and I'll pause again after that. This is measurement of vibration and ground-borne noise.

67. Ground-borne noise is something which you hear in the air in a room, nearly always in a room, you can sometimes hear it out of doors, when the source of the sound is actually underground and the source begins life as vibration. In London, for example, in places above the old Victorian tube lines, which were constructed with rigid rail support and jointed rail, you can hear quite a lot of rumble and clickety-clack from trains going on track in the tunnels. That begins life as vibration. It's transmitted into the tunnel lining, into the soil and up to the surface. And then when it arrives at the surfaces of the room you're sitting in the floor slab or the walls of the room are set into vibration. The vibration is at a frequency which is within the audible range and the floor and the walls behave as if they were loudspeakers and they radiate that vibration as sound in the room. And that's what ground-borne noise is. I'm happy to say – I've taken London as an example – the more recently constructed underground railways in London have resilient support for the track. It began with the Jubilee line extension, which has resilient rail support. Those of you who have experience of Portcullis House in the parliamentary estate will know that the District line runs effectively through its basement but it runs on resilient support and it's very hard to hear any ground-borne noise from the District line anywhere in Portcullis House.

68. That's vibration in terms of ground-borne noise perceived by the human sense of hearing but you can also, of course, perceive it by the human sense of touch or motion if the building wobbles, not through your ears but through your sense of touch or motion, and that is assessed in a different way. It's either assessed using a thing called peak particle velocity or PPV but I'll also be talking about vibration dose value, which is a way of summing the amount of vibration you have over a period of time in a particular mathematical way.

69. But the ground-borne noise that I was talking about, once it gets into the air and is audible, is measured in LAmax, as I was explaining earlier, the only difference being

that the convention is that we use the slow response that I talked about and we have LAmaxS or LASmax – sometimes the S comes at the beginning, sometimes at the end – as our index.

70. But before I move on to government policy I will pause again. I'm happy to answer any more questions.

71. THE CHAIR: Yes, Lord Brabazon.

72. LORD BRABAZON OF TARA: Thank you, Chairman. Mr Thornely-Taylor, I used to live in Fulham near Putney Bridge directly underneath the flight path and one of the most disturbing things was the planes coming in at 4.30 or 5.00 in the morning, if they woke you up. And if they woke you up you tended to stay awake and hear all the rest coming in. Sometimes you didn't wake up and it was all right. But during the day the planes were presumably making exactly the same amount of noise but one didn't notice them anything like so much. Would you like to comment on that?

73. MR THORNELY-TAYLOR: Yes indeed, My Lord. It is known that the most sensitive times of the night are either the beginning of the night when you're trying to fall asleep or the end of the night when you're getting close to waking and you're more likely to be disturbed. But part of the reason why they're more disturbing at night than by day is you will be probably in a lower background noise environment and the prominence and the annoyance value of noise is dependent on the amount that it protrudes above the background, if I could put it that way. During the day there are more things going on. There's more traffic out in the street; you won't be necessarily in a quiet room like a bedroom, or quiet apart from the aircraft, and the amount by which a noise like that exceeds the background will be less. And during the day, you might be trying to sleep during the day but, generally speaking, you'll be engaged in other activities which are not as sensitive to noise as the brain is when either falling asleep or awakening. I hope that helps, My Lord.

74. LORD BRABAZON OF TARA: Thank you very much.

75. THE CHAIR: Lord Snape?

76. LORD SNAPE: As a general question, Mr Thornely-Taylor, what, in your wide

experience, generates the greatest problem to people or greatest number of complaints? Is it continuous noise or is it, picking up Lord Brabazon's point, occasional noise at certain times of the day? I mean how quickly do people adjust to continuous noise as against the point that Lord Brabazon's just made?

77. MR THORNELY-TAYLOR: A lot depends on the matter that I referred to earlier on, which is their attitude to the noise. If, for example, somebody on a neighbouring property starts a machine up which the resident who hears it thinks is completely unnecessary – 'They shouldn't be doing that. Why are doing it; have they got the necessary permissions to do it?' – they're much more annoyed by it than if it is something which they consider to be necessary, like the marshalling yard we were talking about earlier on. And they will accept it more than they will something they consider should be stopped, so to speak. But it's also known that for the same value of a noise index, such as the Leq I've been explaining, people are more annoyed by some types of noise than others. They're more annoyed by aircraft noise for the same value of the Leq index than they are by road traffic noise. And for railways in general, although we don't claim any benefit from it in the HS2 assessment process, for railways in general there is something called a railway bonus, which means that people are less annoyed for the same level of Leq by railways than they are by road traffic and by aircraft. I hope that helps, My Lord.

78. LORD SNAPE: Just to follow up that particular point then, Mr Thornely-Taylor, I used to represent a constituency alongside which the M5, in fact, ran through it and the M6 alongside it. The complaints I got about noise – I also had a couple of railway lines – 95% of them were about the motorway because they said even at 2 and 3 o'clock in the morning, in fact it was worse at 2 and 3 o'clock in the morning, there's so many heavy goods vehicles on there that they found it much more intrusive than the passing of an occasional train.

79. MR THORNELY-TAYLOR: Yes. I think that is a most important point. We are using the same index to measure traffic noise and train noise but the essential thing we must always bear in mind is if you're at a location near to a motorway like the M5, whereas it might have, let's say, a sound level of 60 on the LAeq scale, that is representing a never-ending passage of vehicles, very little in the way of rise and fall. There's never a quiet moment, if I could put it that way, whereas if you're beside a

railway you might have exactly the same LAeq level 60, for our example, in between trains there's no extra sound at all and you're hearing the birds and cows mooing and the normal background if you're in the countryside or you're in a town and you're just hearing exactly the same environment that you would if there were no railway at all. It's only while the trains are passing that there's an influence on the measured sound index. I do think that's something we always have to bear in mind because it's very easy to look at the assessment prediction of level of sound in LAeq from a railway and think that to live there is as bad as living near a motorway. But, as I was saying, you never get intervals of quiet near a motorway whereas in areas affected by HS2 trains in between the passage of the trains the sound level is exactly as it was before the railway came.

80. LORD SNAPE: Thank you, Chairman.

81. THE CHAIR: Thank you very much, Mr Thornely-Taylor. I think you can move on now.

82. MR THORNELY-TAYLOR: Thank you, My Lord. I'll move on to the subject of government policy. I'm now on slide 13 in the P5 pack and the top document, so to speak, is the Noise Policy Statement for England, which came out in 2012, and it has three important aims. The first is to avoid significant adverse impacts on health and quality of life. The second is to mitigate and minimise adverse impacts on health and quality of life. And the third is, where possible, to contribute to the improvement of health and quality of life.

83. When the policy document came out it was accompanied by an explanatory note, which put quite a lot of flesh on those bones of the three aims and it introduced some terminology, which we see a lot of in these Committee proceedings and have done through the passage of Phase One of the Bill and Phase 2A in the other place. We are introduced to two concepts in terms of observed adverse effect level. It comes from lowest observed adverse effect level, which is an established concept in toxicology. If you're considering the consequences of administering a therapeutic drug there is a level at which there is no observed adverse effect and then there's a level at which there seems to be an adverse effect and you have this thing called lowest observed adverse effect, which is known as LOAEL, and we'll be talking about LOAEL in response to

noise issues. Then in the explanatory note to the Noise Policy Statement for England was introduced the additional concept of significant observed adverse effect level, which we call SOAEL and we talk about LOAEL and SOAEL frequently and people haven't any idea what we're talking about but that's what they are. They do have very important consequences in policy terms.

84. Once one has decided what numerical index values you attach to LOAEL and SOAEL, and I'll explain that in a moment, the policy requires that effects above SOAEL are avoided. And 'avoid' means not, well, better if you don't do it; it means do not have effects above SOAEL. I will explain in a moment how the Government puts that into effect in its interpretation but if you're not above SOAEL but you're above LOAEL, in other words there's an observed adverse effect level but it's not reached the significant observed adverse effect level threshold, then the policy requires that you mitigate and minimise the effects, as much as is practicable, between LOAEL and SOAEL. And, in doing that, one has to take into account the matter of sustainable development and also bear in mind that noise is not the only thing to take into account when doing the balancing act between the cost and practicability of mitigating and minimising noise that's above LOAEL. So there is a considerable complexity to the decision-making process as to what you should do, how much money you should spend to reduce noise when you're not so high as to have to avoid it, not so high as to be at a significant observed effect level, but it nevertheless requires proactive management of noise, taking into account the guiding principles of sustainable development.

85. MR STRACHAN QC (DfT): Mr Thornely-Taylor I think you may have frozen for a couple of seconds, at least on my screen. I just wondered whether you could just recap the last minute or perhaps, well, 30 seconds. You cut off. I'm sorry, My Lord, I thought I should intervene at that point.

86. MR THORNELY-TAYLOR: What were the last words that I was heard to say?

87. MR STRACHAN QC (DfT): Well I – you were just explaining the difference between LOAEL and SOAEL.

88. MR THORNELY-TAYLOR: Yes.

89. MR STRACHAN QC (DfT): I suspect you may go back too far, but if you could

just pick up on that theme again, I'd be very grateful, Mr Thornely-Taylor.

90. MR THORNELY-TAYLOR: I was explaining first that government policy requires that effects that are significant observed adverse effect level have to be avoided, and that means they should not be there, not just it'd be nice if you didn't do them. Between the onset of observed adverse effect levels, between LOAEL and SOAEL, the policy is to mitigate and minimise effects, but that involves a balancing act, looking at the cost of mitigating and minimising, taking into account Government's policy on sustainable development, and weighing the total benefit that the community would achieve by the institution of noise mitigation measures, and weighing that against the cost. And then the bottom bullet point on this slide is quite important, in that the actual Noise Policy Statement for England doesn't put numbers to LOAEL and SOAEL. The words it uses are, 'It's not possible to have a single objective noise-based measure that defines SOAEL. It's applicable to all sources of noise, in all situations, and SOAEL is likely to be different for different noise sources, for different receptors, and at different times.'

91. Now, in the eight years since the Noise Policy Statement for England came out, there have been a lot of major infrastructure projects that have gone through their processes – their power-granting processes – not least Phase One Act of Parliament for HS2, and we are now able to look at precedents and a lot of the works already being done in working out what numbers we should assign to LOAEL and SOAEL, and I'll be showing a slide illustrating what they are. But having done that, it's then possible to look at all the receptors, all the people living beside a scheme, such as a new railway, identify those that are between LOAEL and SOAEL, look at the balance of practicability in applying mitigation and minimisation works for them, and identifying the people who have significant observed adverse effect levels and applying measures to avoid that happening.

92. Now the important thing is that it was established fairly soon after the publication of the Noise Policy Statement for England that the Government considered you do avoid significant observed adverse effect levels by providing sound insulation, in other words, double or triple-glazing and alternative ventilation to façades, and that is the consequence, in projects of this kind, of there being a significant observed adverse effect level. But among other things, sound insulation to the affected dwelling is provided.

And my next slide, which is number 14, is headed, 'HS2 Implementation of Government Policy', and back in the early days of the scope and methodology report writing for Phase One of HS2, the assessors – environmental assessors – looked at established practice, they looked at research results, they looked at guidance in national and international standards and, in particular, all the documents that have been produced by the World Health Organization, and they set up an independent review group, which looked at what the environmental assessment team had concluded, in terms of assigning levels to LOAEL and SOAEL, and that review group – from academic, industry and government employees – called the acoustics review group, they came back with anything they felt was not right or needed adjustment, and we then ended up with a table of LOAEL and SOAEL levels, which I will shortly show.

93. In addition to that, we have another tool available to do the other part of the equation, which is looking at the cost effectiveness of benefit of noise mitigation measures, and that's the Department for Transport's web-based transport analysis guidance, known as WebTAG, and that's a deterministic system where you enter parameters to do with the do nothing baseline noise levels, the noise that you get in the scheme at a future year, and it will monetise the effect of the noise in terms of the response of the populations affected, and it enables you – assists you – in doing that difficult balancing exercise between the cost of mitigation and the benefit that it brings.

94. In the next slide, which is number 15, is the result of that work. It tells us what LOAEL – lowest observed adverse effect level – and SOAEL – significant adverse effect level – is in numerical terms. It does it by time of day, and in the daytime it's fairly straightforward. It uses that index that I described, the LpAeq 16 hour for daytime and eight hour for night time, and the LOAEL for day time is 50 dB and the SOAEL for daytime is 65 dB. The levels are much lower for night, as we were discussing a short while ago. Sensitivity at night is greater, and the LOAEL in terms of the LAeq index is 10 dB less, 40 dB, and the SOAEL also 10 dB less than for day, 55 dB. But in addition, at night, we look at something over and above the LAeq index. At this point I need to explain something a bit complicated that, where we're looking at LAeq in terms of day and night exposure, those numbers I've just described, 50 dB – 65 dB, 40 dB – 55 dB, that is a prediction of what the sound level is in a location, ignoring the effect of the presence of the building. But we're also concerned with the maximum sound level, due

to the passage of individual trains.

95. I explained the LAFmax index earlier on, and that's a secondary test of whether people are going to have their sleep disturbed by the passage of a train, and when we're looking at maximum levels we do take into account the consequences of there being a building present. It is unfortunately a complicated thing to do, but there are reasons based on the way in which the underlying research was expressed, and the LOAEL for the maximum sound level due to the passage of a train at night is 60 dB outside the façade – that's from any event – and the SOAEL is two numbers, depending on the number of train movements that occur during the night. In locations where there are fewer than 20 nightly train pass-bys the SOAEL for the external LAFmax is 85 dB, but in case where there are 20 or more train pass-bys in the night period of 23.00 to 07.00 the SOAEL is 80 dB, and that applies to a large number of the locations for which predictions are made in the environmental statement.

96. I'll turn now to those predictions in the environmental statement within the volume 5 set of documents. There are both noise mapping books – noise map books – and tables, giving a vast amount of information about the predictions of the noise effect of HS2. It's very important that petitions and others interested in what the noise effects will be at a particular location to go to volume 5, because the quantity of information there is very great, sometimes overlooked by people who don't realise it's there. There are two fundamental things done in the processing of these predictions. One is to look at something called impact, which really is the noise change. It's separate from considering significant effects. It's the numerical difference in the overall noise level after the opening of the railway, and in fact up to its maximum state, when everything is complete and open and all the trains are running – it's the difference between the overall noise level with the railway there and what is the baseline, without the railway, and we get magnitudes of impact, which are colour coded yellow, orange and red according to the magnitude of the noise change.

97. But that's only one of the things which determines the significance of the noise effect. We've been talking about SOAELs – significant adverse effect level – but the word 'significant' also crops up under a different heading, which is 'Environmental Assessment Law', because one is required to identify likely significant effects in carrying out environmental assessment, and we end up with quite complex tables and

maps in volume 5, which show – effectively show – three sets of data. They show predicted sound levels, they show impact in terms of noise changes, and then they show whether those noise changes have been found to be a significant effect by the professional environmental effect assessors, which depends upon non-numerical things or not so purely numerical things as the size of a community that is affected by noise change. We will come back to these colour codings that are on slide 16 when we look at an example table from volume 5.

98. In slide 17 we'll see an example of one type of noise map that's in volume 5. These show the actual, predicted levels in LAeq and additional information about identifying receptors, including those receive noise levels sufficient to require the provision of sound insulation. But the map that we've spent most time on, when looking at petitions, is the one in slide 18 – page 18 – V5(18) which, though it's not as colourful, actually contains very specific information from the point of view of implementation of government policy. It shows us a contour of the areas within which the noise, in LAeq terms, is above LOAEL. That's the grey contour, the widest one. There's a slight oddity about the noise predictions, which is that those LMax numbers, which can also determine LOAEL or SOAEL, that I was explaining – 60 dB outside the façade at night, 80 dB or 85 dB outside the façade by day – they can actually give you a conclusion that the property is above LOAEL in a location which is further from the railway than the position of the contour of LOAEL expressed in terms of LAeq. At the beginning of Phase One process it took a lot of words to explain this, so in Phase 2A we introduced this system of the little black squares, which identify properties that do receive noise above the LOAEL threshold when it's considered in terms of LMax outside the façade and, as you can see from this example, some of them are further from the railway than the edge of the LOAEL contour expressed in terms of LAeq.

99. In the middle of this chart we see pink contour, and that's the contour of SOAEL, and fortunately there are not many properties within that, but there are some, and they are identified by symbols and, if we look about three quarters of the way to the right, along the trace of the railway, past some letters OSVO1-CO1 we'll see the pink contour there does a little turn in towards the railway and there is a square with a star in the middle of it, and if the resolution of the slide was great enough we'd see that the presence of that star indicates that that property is eligible for sound insulation in order

to avoid SOAEL, in accordance with government policy.

100. And before I pause for questions, I'll just show the way this is presented, in volume 5. In slide 19 it's just one example of page after page of addresses, in which a large amount of information is provided. We get the daytime and the night time LAeq level, numerically. We get the maximum sound level. It's actually given us two numbers: one is for HS2 trains, and the other is if there should be running on the system European trains, which only just meet what is known as the TSI standard – the Technical Specification for Interoperability. It's actually not expected there will be TSI trains now. But the ES follows the practice that began with Phase One and gives two numbers, one for HS2 trains and then after the oblique stroke, the second is for TSI trains.

101. Then there are three columns showing what the baseline noise levels are, day, night. It does show what the maximum baseline levels are, although they don't play a formal part in the assessment process. It gives you differences between 'do something' – that's the opening here – plus the baseline, minus the baseline, and the change is highlighted in coloured blocks, according to the magnitude of that difference between the future noise level with the railway system operating, minus the baseline.

102. Now, as I was explaining, just because you've got a noise impact – in other words, a noise change – doesn't automatically lead to a significant effect conclusion. Because that noise change might be from a low base to a finishing level which is still below LOAEL, for example. On the other hand, you could be above LOAEL, not above SOAEL, but the effect can apply to a large community, and then the judgement is made that there is a significant effect on a community basis, and the important column is the one on the right, where you get some pink coloured boxes, and those are the ones where there is a significant effect, in environmental assessment terms: possibly because the absolute level is above SOAEL – in which case you're straight into a significant effect – possibly because it's above LOAEL and the effect is for a large community. And I will pause there, because I'm moving onto a slightly different aspect. I've given, I realise, a huge complexity of information, and I'm sure there'll be questions.

103. THE CHAIR: I wonder whether you could take us through the significance of the criteria to the right-hand side of this slide: 'type of effect'. Some are marked as A, some

are marked as S and then you've got 'types of receptor' and so on and so forth. Do we need to know about these things?

104. MR THORNELLY-TAYLOR: You do if you're hearing a petition about a specific property. They give you a wealth of information. The S is for 'significant', and it arises in the case of the two properties to the middle of the slide, Shaw Lane Farm, Echills Farm, and they are significant because of the numbers in the third column after their name, the one headed 'max' with three stars, because the max is over 80 dB in both those cases, and the number of trains in the night period is more than 20 in their case. So the trigger for SOAEL at night is 80, and they're above that, so they automatically get pink box in the right-hand column, because there is a straightforward significant effect. On the other hand, you can get a significant effect, such as the first line, as a consequence of a noise change even though, after the change, the overall noise levels are not above the fixed thresholds for LOAEL and SOAEL because there's a community of the order of 25 properties there. The environmental assessors have concluded that there is a community effect – a significant effect on a community basis – and that's why they get a pink box there.

105. And readers of this volume will find it worthwhile just looking at the funny little symbols you see. There's a hash sign in the first line, and a tilde mark in the last three lines, and they all have their own particular meaning. If you look at the footnotes to the tables in the volume. As I say, there is a surprisingly large amount of detailed information in this part of the volume 5 books, and it's to be highly recommended the petitions and others – not necessarily petitioning but concerned about what the future noise environment will be like – they'll be able to look here. If they can't find their own address there, they'll find a nearby property and there is a wealth of information explaining what will be the outcome of the completion and the operation of HS2.

106. THE CHAIR: Thank you.

107. MR STRACHAN QC (DfT): My Lord, if I just indicate that in the volume 5, where these tables appear, the abbreviations are – there is a key which explains the abbreviations of the type that you had identified: A, for example, being annoyance, S, sleep disturbance, I believe, and NA, no adverse effect. But they are set out in more detail in the key. But we haven't captured that on this slide I'm afraid, but for those

who are interested in each of those terms they are present in the environmental statement.

108. THE CHAIR: Any questions from members of the Committee? Well I think you can pass on then, Mr Thornely-Taylor.

109. MR THORNELY-TAYLOR: Thank you, My Lord.

110. THE CHAIR: We have 19, do we?

111. MR THORNELY-TAYLOR: Yes, we've been looking at 19, at the coloured boxes. I'll move on, if I may, to number 20, and this is telling us what LOAEL and SOAEL numbers are for ground-borne noise and vibration, primarily from the operation of trains in tunnels. Numbers there in terms of LASmax. 35 dB for LOAEL, 45 dB for SOAEL, and then values in terms of the vibration dose value for the version of vibration that you feel, rather than hear as re-radiated sound.

112. I'll now move on to a little more about the relationship between these predicted sound levels and characteristics such as train speed, and explain a bit about the different sources on the train and how they vary with train speed. I'm looking at slide 21 now, and this is headed, 'Operation Noise – Contribution of Sources', and we look at the fundamental case, which is open country, flat ground, no obstacles between the listening point and the track. Had the Committee been to sound lab to hear demonstrations they would have heard a demonstration of what it sounds like when an HS2 train passes in these conditions, and the feature of this slide, which is most important, is the way that the different sources that make up the overall sound source of a passing train contribute to the total, and their relationship with speed, and all trains make noise because steel wheels run on steel rails, and that's known as rolling sound.

113. All trains produce some sound due to the traction equipment – in other words, the motors and gear boxes and things. But as speed increases, you start to get aerodynamic sound, which may be because the train – the bogies and the coupling between the train are moving through the air at speed, or it may be due to the current collection on top of the train and, on top of a high speed train, as is the case for a lot of commuter trains and ordinary trains if I can put it that way, there is a thing called a pantograph, which is an angular frame that has a current collection bar on the top, which touches the catenary

cable carries the electricity above the railway, and that device, when it's moving fast through the air, produces a lot of turbulence, and the turbulence is manifested as sound, and it increases quite steeply with increase in speed. Looking at slide 21, the solid blue line is the total pass-by sound and, at low speed, 100 kilometres per hour – left hand side of the chart – it's the main – it's main contributor is rolling sound, the rolling of the wheels on the rail. As we move up in speed, 200 and 300, we see body aerodynamic sound rising at a faster rate with increase in speed than rolling sound, and the same is true of sound from the pantograph. And we can see, for that reason, that as we move above 300 kilometres an hour there's a slight upward curvature in the solid blue line with increase in speed.

114. But what's interesting, if we move now to the next page, page 22, and we now assume there's a 2 metre noise barrier in place, because – as I'll be explaining – the effectiveness of noise barriers is very sensitive to the relative height of the source – i.e. the rail, in the case of rolling noise, and top of the barrier and the height of the receiver, a noise barrier of this kind is much more effective in reducing rolling sound than it is in reducing aerodynamic sound, particularly from the pantograph right high up on top of the train. For simple geometric reasons the difference in height between the barrier and the rails is much greater than the difference in height between the top of the barrier and the pantograph, and the consequence of this is that when you've got a train running behind a noise barrier, the aerodynamic sources are much more influential and they produce a slightly greater upward curvature of the solid blue line. The thing to bear in mind is that because of the reduced geometric benefit for sources as high as the pantograph, there comes a point when further increases in barrier height are much less effective than the first metre or two, when you first introduce the barrier, because these high-level sources – high-level in terms of height above rail – are much more significant in relative terms than – relative to the rolling noise – than is the case with no barrier there at all.

115. I'm going to move on to the effect of the track support system. So I'll pause to see if there are any questions on that matter. I have got another slide about barrier heights further on.

116. THE CHAIR: Yes, Lord Horam?

117. LORD HORAM: You've got a train speed along the bottom. What will be the normal train speed of an HS2 train?

118. MR THORNELY-TAYLOR: 90% of the trains will be timetabled to run at 330 kilometres an hour. It's assumed in the noise assessment that 10% will run at 360 kilometres an hour, to catch up lost time, and that proportion of maximum speed and somewhat lower than maximum speed trains is what is expected to occur. There is a technical capability to run at 400 kilometres an hour in terms of the specification of the railway, but trains will not run faster than 360 kilometres an hour.

119. LORD HORAM: Thank you.

120. THE CHAIR: Yes, Mr Strachan.

121. MR STRACHAN QC (DfT): My Lord, I am sorry. I might just take this opportunity, while there's a brief pause, just to mention that the table on page 19, those letters that I spoke to soon in identifying exactly what they are. They are referred to in the environmental statement, but I think the letters that you have in mind, A, NA and S actually stand for adverse, no adverse or significant, and what I was being referred to as sleep disturbance, it was the particular example as to why the S, I think, arose there, because of the high levels of maximum. It rather illustrates the point that I shouldn't have jumped in and referred to a key without having the key in front of me, and I apologise for that but I hope at least I corrected that so that Your Lordship understands the letters that you asked about.

122. THE CHAIR: Thank you very much.

123. MR STRACHAN QC (DfT): And I'm sorry for interrupting Mr Thornely-Taylor I think who was otherwise going to turn and help you with the question of track support systems.

124. THE CHAIR: Yes, I think we've moved to 23. Slide 23.

125. MR THORNELY-TAYLOR: We have indeed, My Lord, yes. It's a difference between Phase One and Phase 2A. In the assessment of noise from Phase One it was assumed that track would be like the picture top right on page 23: ballasted track, rail fixed to concrete sleepers by clips and pads with stone chips holding it all in place

between them, and when the design moved on and we reached the stage of doing the Phase 2A environmental assessment the decision had been made to move to the more modern form of track support, which is simply referred to as non-ballasted. It is actually a concrete slab – quite a complex concrete slab – with a more elaborate form of rail support than you get in ballasted track, and there are differences between the noise characteristics of those two types of tracks.

126. When the decision was first made, and the environmental assessment team set about doing the new predictions, they took a very pessimistic view of the consequences of that change in the track design principle, and they assumed, quite reasonably on the basis of the then available information, that slab track, as one can call it for short, was 3 dB noisier than ballasted track. There are two things that play in that case. Ballast actually does behave as a bit of a sound absorber, although it's not like mineral fibre that you see in acoustic tile. It nevertheless has air interstices which provide some sound absorption. But the main thing is that the rail support system in ballasted track was considered to be of such a nature that sound propagating along the rails as vibration decayed more rapidly than it would with ballasted track, because ballasted track has softer rail pads, and the main consequence of that is that the effective length of the sound source – which is, among other things, the absence of a noise barrier, vibration of the rail which then radiates sound – the distance over which that occurred was greater in the case of slab track and, therefore, there was a higher fundamental source sound level.

127. I showed in a couple of slides back that rolling noise is only one of a number of sources, and when you combine them all together – as the third bullet point on page 23 explains – combine them all together in the ES, the overall increase of 330 kilometres an hour was 1.5 dB as a result of switching from the ballast assumption to the non-ballasted assumption. But research work has been done since then, which shows that what goes on in the track is much more complex than the simple explanation I've given, and the nature of the what are called base plates – the fastenings between the concrete slab and the rail – is such that you don't get the lengthening of the effective source, or to put it another way you don't get a lesser decay rate in the rails than was thought, and the current position is that the overall noise level of the two types of track support will be very similar between ballasted and non-ballasted. So, consequently, there is a pessimistic assumption in the ES which sort of resulted in slightly higher numbers than

will probably be the case.

128. My next slide is 24. We get into the subject of mitigation. In other words, ways of reducing vibration and ground-borne noise. The overriding requirement on the train designers, the track designers, to reduce noise. Train design and maintenance is an extremely fruitful area in which to work. I talked about the aerodynamic sources as being very important, and clearly there are ways of improving the aerodynamics of trains, reducing air turbulence. I'll be showing a picture in the next slide of an example of that. And I've also talked about track design and the influence that can have on sound radiation from railways. We of course have continuous welded rail, which means you don't get the effects you get along some old suburban railways, where you get a clickety-clack noise from rail joins, and I've talked a bit about the importance of resilient rail support – the base plates between the slab track and the rail – which also play an important part in controlling the amount of sound that's generated and radiates.

129. Slide 25 is an example of the aerodynamic noise effect I was talking about. There's a picture, top left, of this pantograph device. It's called a pantograph because it vaguely resembles a device that draughtsmen used in the 1950s to trace drawings and make a larger copy of another by moving it about a drawing board. Most people will never have seen one I think. But you can see that aerodynamically it's likely to cause noise, simply by rushing through the air at speed, because there will be air turbulence generated as the components that protrude above the top of the train move through the air at 330 kilometres an hour. And there's a lot that can be done. The picture on the left is from a European train, just compliant with the TSI that I mentioned – the Technical Specification for Interoperability – it's got no fairing, as they're called. Turbulent air created not just from the bit that sticks up, if I could put it that way, but also from the well, the pantograph well, that space on the roof of the train into which the pantograph goes when it's not in use.

130. There's a lot of turbulence caused at that point, and the people, of course, who are first on the scene with high speed trains, the Japanese, discovered early on, with the Shinkansen system, that there were noise issues that needed addressing, and one of them was this question of aerodynamic noise from the pantograph. And those of you who've visited Japan recently will see that the modern generation of Shinkansen trains have many features on them for noise reduction. There's a picture here showing shrouding

around the pantograph well, that grey angled device covers the pantograph well. There's a sort of wing on the corner of the body of the train, which also helps to smooth the air flow and reduce radiation of sound from that source. But you will also see on modern high speed trains in other countries things like fairing between the ends of the vehicles of the train and improvements to the aerodynamics of the bogeys and, particularly, to the front of the train because there's a lot of aerodynamic noise created at the leading bogey, the leading axle of the train, and considerable reductions in noise are possible by these refinements. The ES has been very pessimistic in its assumptions about the benefit that will be obtained by this sort of thing. It's just a 3 dB reduction assumed for pantograph aerodynamics. But, in fact, much more than that can be achieved.

131. THE CHAIR: Before you move on, can I ask what the assumption was on which you built slides 21 and 22? Do you remember? These were the graphs showing the noise effects of the pantograph in relation to the total sound.

132. MR THORNELLY-TAYLOR: Yes. They assume, My Lord, that the track is non-ballasted, and they assume that the pantograph has modest noise attenuation, such as to improve the source noise level of the pantograph and the pantograph well by 3 dB, which is modest in comparison with what can actually be achieved with the most up to date pantograph designs.

133. THE CHAIR: Yes. Okay.

134. MR THORNELLY-TAYLOR: Which takes me to...+

135. THE CHAIR: I'm sorry, before you move on, Lord Haselhurst has a question.

136. LORD HASELHURST: Could you tell us how far the research has gone with HS2 to find the optimum benefits that can be achieved in the design, particularly of the pantograph and a well that might help to suppress the noise?

137. MR THORNELLY-TAYLOR: Well we are already at the position where we know that devices such as the one shown on page 25 have substantial benefits. That's a minimum assumption that the HS2 trains will have what are known as fairing on the pantograph well and around the current connection equipment. The effort to achieve

noise reduction in the HS2 programme is continual. All the time there is work going on and research being carried out and the procurement process will place the burden on the designers and suppliers of the rolling stock to use the most effective method of noise reduction that is achievable.

138. LORD HASELHURST: Thank you.

139. THE CHAIR: Yes, I think it moves now to is it slide 26 is the next one?

140. MR THORNELY-TAYLOR: 26. Yes. I'm going to talk a little more about noise barriers, which I've already briefly explained. Here's an aerial picture of a noise barrier on what used to be called the Channel Tunnel Rail Link and we now call HS1, High Speed One. This is at a location between Lenham and Ashford. It's called Charing, and you can see a three-metre noise barrier. Three metres above the railhead level. 3.7 metres above ground level. And there it is to protect that dwelling which we see, it's a smallholding we see, to the left of the picture, just to show what noise barriers look like, and I think most people are fairly familiar with them. They're fairly straightforward structures. They may either be a panel-based structure of that nature, which has a sound absorbent lining to it, but they may also be natural features: bunds and mounds alongside the track, on top of which a smaller barrier can be placed.

141. As I'll show in the next slide, which is 27, we always have to keep in mind that the fundamental geometry of noise barriers – we can see there the elements of the system, the house, called the 'receiver', on the left, the train labelled 'source', on the right, and before we put the barrier there, as I was explaining earlier, the main noise source is the rolling noise where wheels and the rails meet, down at rail level, and that's the starting point. And the thing which determines how effective a noise barrier is, is the difference between what's shown in this slide as an orange line – that's the line that goes from the source, that's the railhead, to the top of the barrier and then from there to the window of the house, the receiver. And the other line there is a purple line, which is drawn straight from top of the railhead to the window of the house, as if the barrier wasn't there. And it's the difference in length between that orange line, and the purple line, that determines how effective the noise barrier is. It's called the path difference.

142. And fundamental geometry tells you some very important things. The most important of which is that that path difference – the difference in length between the

orange and the purple line – is very dependent on where the top of the barrier is, relative to the position of the source and the position of the receiver. If it's closer to one or the other the path difference goes up quite steeply. If you move that barrier – you could move it right up to the edge of the gantry with the current collection equipment – that path difference would grow. And similarly if you moved it closer the receiver it would grow, but less so where you've got a height difference as big as this. In fact, if you took the noise barrier right up to the façade of the house you would find that it was only just above the line of sight, the purple line.

143. But in all noise barrier calculations, that's the fundamental thing to determine, and it's crucial that once you've got a noise barrier in place, adding to its height, while it does increase that path difference, you get a law of diminishing returns: the extra benefit for extra height on the barrier becomes quite disappointing, if I could put it that way, as you go higher, and there actually comes a point when you cease to get any further benefit because of the effect of wind and turbulence and scattering of sound transmitted over the top of the barrier. Those are the fundamentals of noise barriers. I'm going to talk about other mitigation topics, but I can pause there if anything arises from that.

144. THE CHAIR: You talked about geometry, but what about the mathematics? Is there any given distance, on your picture there, at which point you can be sure that the noise barrier will have no effect?

145. MR THORNELY-TAYLOR: It will only have no effect if it's – if the top of the barrier is well below the line of sight. There's a convenient mathematical axiom, which is that if the top of the noise barrier just reaches the line of sight the effect of the noise barrier is a noise reduction of 5 dB. It's quite useful to know. But as you go higher, as the top of the noise barrier protrudes further above the line of sight, you'll get more than 5 dB and it will go up – a very, very high noise barrier can give 20 dB. But the cost goes up dramatically and incremental heights produce a marginal improvement in noise level much less than the actual, physical, increase in height.

146. THE CHAIR: Thank you.

147. MR THORNELY-TAYLOR: On slide 28 I talk a bit more about mitigation, in terms of the construction stage. Because clearly the construction phase is lengthy, in many locations, and there's a large amount of plant required. Fortunately, there have

been a large number of major infrastructure projects with significant construction activity, and the prediction and the control, the monitoring of construction noise and the mitigation of it, both at source and at the receiver, is now a very well-trodden path. There is a very well-established protocol for predicting the noise, assessing its effect, identifying eligibility for receiver mitigation, in terms of noise insulation if the levels are high enough. But at the source side there have been enormous improvements in the sound emitted by construction plant. We still work to a British Standard which has data in it for construction noise levels dating from the 1980s. But I think all of us have, at some time or other, visited a construction site and have been impressed by the fact that, first of all, you often see much less activity than you would expect for the size of the site and the number of items of plant there, but the plant that is working in – on a modern site, is noticeably quieter than was the case 20, 30 years ago when the relevant standards were first produced. On the whole, major construction projects, of which there have been many in recent times, have proceeded through to completion with a very satisfactory process of control, monitoring and mitigation, and it's a well-trodden path which we well understand.

148. And that takes me to the last slide, which is a straightforward list of some important documents for the HS2 project, known as the information papers. They actually do contain information, but they're much more significant than carriers of data. They form part of the environmental minimum requirement system, which Your Lordships have heard about, and there are five separate documents and, in particular, E10 deals with ground borne noise and vibration and the operation of both the temporary and permanent railways. E11 deals with control of noise and the operation of stationary systems – that's fans and things of that nature. Monitoring operational noise and vibration monitoring framework, and E13 deals with control of construction noise and vibration. And that takes me to the end of my formal presentation pack. I hope I've covered everything Your Lordships wish to hear about. I'm very happy to expand on anything else that I can help with.

149. THE CHAIR: How do we find the information papers? Is that a matter that will be drawn to our attention by you, Mr Strachan, as each case comes up?

150. MR STRACHAN QC (DfT): My Lord yes, that's right. The information papers are generally available. They're public documents. I think they're on – I'm not entirely

sure exactly the website address and they are available on the HS2 website address. But where we are referring to the contents of the information papers, particularly in respect of petitions, we'll ensure that the information paper's available to the Committee, or the relevant extract for the response to a particular petition. Because there's quite a lot – there are a lot of information papers. I think the Committee originally had a hard copy of them available, but obviously to address the current situation we'll make sure that the relevant information papers are available in response to particular petitions.

151. THE CHAIR: Thank you very much. That would be very helpful. Now, before I bid farewell to the witnesses, any member of the Committee have any other questions? Well, Mr Thornely-Taylor, thank you very much indeed for your presentation. I think we are greatly assisted by the fact that we have the slides available to us to look at as the hearings progress, and we'll take the opportunity of looking back at them from time to time to remind us of what you've just been saying. Can I thank you on our behalf very much indeed for your evidence? And I think now at this point, since there are no further matters for us to deal with in the public hearing, I can simply adjourn the hearing and say that the next public meeting will be at 12.45pm on Wednesday, 22nd July. So from this point the meeting is adjourned.