MINUTES OF ORAL EVIDENCE

taken before the

HIGH SPEED RAIL BILL COMMITTEE

on the

HIGH SPEED RAIL (WEST MIDLANDS – CREWE) BILL

Tuesday 27 March 2018 (Afternoon)

In Committee Room 5

PRESENT:

James Duddridge (Chair)
Sandy Martin
Mrs Sheryll Murray
Martin Whitfield
Bill Wiggin

IN ATTENDANCE:

Timothy Mould QC, Lead Counsel, Department for Transport

WITNESSES:

Rupert Thornely-Taylor, Acoustics and Vibration Expert (HS2 Ltd)
Tim Smart, Chief Engineer, HS2 Ltd

<u>IN PUBLIC SESSION</u>

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(At 4.00 p.m.)

1. THE CHAIR: Thank you very much for the sound demonstration. It was very, very helpful. We very much appreciated you explaining yesterday in layman's terms everything. We're now moving on to government policy. We will complete noise tunnelling and traffic today. So Mr Mould, if you can arrange your timings as you choose, as long as we finish on time I don't mind how we divvy it up.

2. MR MOULD QC (DfT): Certainly.

3. THE CHAIR: Mr Thornely-Taylor, we correctly identified you as well now on your nametag.

HS2 Ltd

Presentation by Mr Thornely-Taylor

4. MR THORNELY-TAYLOR: Thank you very much, sir. Government policy has its origins in a policy document called the Noise Policy Statement for England, which was originally issued in 2012. Its fundamental aims have been reproduced in subsequent noise policy statements and, in particular, in the planning practice guidance, which I'll come to in a moment. Its fundamental aims are as set out in the slide, to avoid significant observed adverse effect levels, which is very important. If you're below the significant adverse effect level but above the lowest observed adverse effect level, you have to mitigate and minimise the noise but it doesn't prevent the scheme being permitted. All this is done within the context of the government policy on sustainable development. There's also the injunction where possible to contribute to the improvement of health and quality of life.

5. When the Noise Policy Statement for England was first issued it had an explanatory note attached which is where this concept of the observed adverse effect levels was fleshed out a bit. The lowest observed adverse effect level is a concept, which you find across toxicology beyond noise. You can Google it and find it being referred to the effect of drugs and things like that. So it's a concept well understood. The significant observed adverse effect level was something introduced by this policy document. We then moved on to the web based planning practice guidance, which gives more information about how to interpret these phrases and adds an additional

category called an unacceptable level. This fundamentally underpins everything that we do in the promotion of major infrastructure projects through the separate national policy statements for different types of development. The important thing is that the Government has not expressly told us what numbers to put against these descriptive terms of lowest adverse effect level. HS2, like everybody else promoting a major scheme, had to consider what was a reasonable set of numbers to attach to these concepts. It did that and these decisions were tested through a group of people called the acoustic review group which was a group of the great and the good outside HS2 that challenged all the thinking that was going on at the time, which led us to a setting of numerical values for the guidance that's in the high level policy documents.

6. In a moment I will show the tables as giving the numbers that were attached to the effect levels but the slide before that shows us that there's an additional technical way in which the effect of noise is weighed in the assessment of mitigation effects. That is another web-based resource. It's called Transport Analysis Guidance; because it's web based it's known as WebTAG. This is quite an important tool which is used both in highways and railways and airport developments which enables you to turn noise changes into monetised values based on research which has done to equate the monetary value that people associate with changes in noise level. It makes it possible at a particular location to come up with a figure for the cost of the noise change that a scheme will bring about so that you can balance that against the cost of mitigation measures such as noise barriers and give effect to the requirement in the noise policy that you don't just take account of noise levels but you have to take into account the economic and social benefits and other non-noise aspects of the process.

7. So if we look at the tables that have now been through the Phase One parliamentary process, we had some discussions with some petitioners as to whether they were right but at the end of that process they were adopted and they are now the HS2 established levels. We've got separate sets of numbers for daytime and night time and the middle and the right hand column are the numbers associated with the lowest observed adverse effect level and the significant observed adverse effect level. When we were in sound lab and we heard the simulations for Hopton and Great Haywood I showed extracts from the environmental statement with maps coming up on the subsequent slide. We needn't dwell on them as we've already looked at them, showing

the extent of the LOAEL as we call it and SOAEL in Leq terms. But I also highlighted the fact that this third row, the night time maximum noise level actually identified some properties further out than the Leq based lowest observed adverse effect level and you may remember seeing those little black squares in sound lab showing that that is actually the most sensitive test.

8. We also saw in sound lab, and I needn't dwell on these, the fact that where there are big noise changes affecting a community even if it is not necessarily within any of the contours, the environmental assessment professionals would reach a conclusion that there was a significant effect there.

9. MR WIGGIN: Just before you too far on this one, I was just checking back at the sheets you very kindly gave us which showed the sounds that we heard today. I thought that the figures were lower than the ones that were on the screen as the established HS2 agreed levels?

10. MR THORNELY-TAYLOR: Yes, some were in Great Haywood the Leq was 44 or 45.

11. MR WIGGIN: Yes.

12. MR THORNELY-TAYLOR: And the little red star showing where we were notionally standing to experience the simulation was outside the lower contour. That's because the number was less than the 50 figure which is where the edge of that contour was.

13. MR WIGGIN: Could you just remind the Committee when it was on 44 what the conditions were? Because we were standing where we were, you said that, but were that the windows shut at night?

14. MR THORNELY-TAYLOR: No, the numbers are calculated outside. We did have some simulations to hear what it was like if you were in reality inside with an open and a closed window.

15. MR WIGGIN: Yes.

16. MR THORNELY-TAYLOR: But the numbers we're looking at and the numbers

which I read out are outside noise levels.

17. MR WIGGIN: This was where the cars were going past was it?

18. MR THORNELY-TAYLOR: Yes. That's right; that was Great Haywood.

19. MR WIGGIN: Right.

20. MR THORNELY-TAYLOR: I did tell you what the maximum level was inside with the windows closed.

21. MR WIGGIN: You did.

22. MR THORNELY-TAYLOR: But we don't use inside levels for the purpose of this assessment system. It's all done on the basis of outside levels. Largely because that removes the uncertainty you get when somebody's house might have different room size, different window size. We'd get into a lot of difficulties if we try and do indoor noise.

23. MR WIGGIN: No, no that's fine. I just wanted to bring it back to what we actually listened to relative to what you're saying. That's all I was trying to achieve.

24. MR THORNELY-TAYLOR: It's quite interesting. We did listen to two different cases. At Hopton we were inside the LOAEL contour in a community which also had some properties further back that would have triggered lowest observed adverse effect level on the basis of their maximum level at night. At Great Haywood we were outside the contour but because it's a big community with lots of properties with little black squares around them, that was an interesting place to listen so you could hear what it actually sounded like in a case where we were at just enough noise to warrant necessitating mitigation and minimisation according to the policy.

25. MR WIGGIN: Thank you.

26. MR THORNELY-TAYLOR: The next two slides are maps. I didn't show you this one and we don't often need it. It's a companion to the grey contour that follows. This shows the actual Leq levels but it's not as interesting in policy terms as the next one, which we concentrated on in the sound lab. That grey area is the area that is lowest observed adverse effect level. The pinkish area is significant observed adverse effect

level on the basis of Leq in both cases. We have the interesting group of dwellings with the black squares around them, which are the ones that do require mitigation and minimisation on the basis of the maximum sound level at night.

27. The next slide is another extract from volume 5. I showed you a small extract from volume 5 in sound lab. It's a very important part of the ES. Some petitioners overlook it and don't realise how much useful information there is in these tables. What we get is location by location, first of all for the scheme-only 15 years after opening, the day and the night and the maximum sound levels. Two numbers are given for the maximum sound level because we have basically the HS2 train to assess but in theory a train could run on the system which is just compliant with something called the technical specification for interoperability, TSI for short. They could be slightly higher in maximum noise level. In reality you will have heard from Andrew McNaughton about trains that will run. The HS2 train is the principal case to address. We have another three columns which are what we get without the scheme. There is a column of maximum noise levels. We don't use that in the assessment process formally. It may be a bird singing. It may be somebody starting a lawnmower. It may be somebody walking past the microphone and shouting. It's not particularly relevant and it's not a formal part of the assessment process.

28. Then we have the combination of the scheme and the baseline. Then the column with the red and the yellow is about noise change. Noise change doesn't figure in government policy but it is of interest to environmental assessment professionals and, as I was saying earlier, where there's a community not necessarily within the contours but there is a big noise change the assessor may conclude that is a significant effect on a community basis. If that happens the last column on the right gets this pink shading.

29. MR MOULD QC (DfT): You will find that we will use the grey and pink shaded contour maps and tables which broadly follow this format quite regularly when we're providing our evidence in response to petitioners that raise concerns about airborne noise. I hope I can reassure you by saying that I expect the definition of the slides to be better than you've seen on these specimen exhibits.

30. THE CHAIR: Would it be possible to have an example so we can just check that we can read them?

31. MR MOULD QC (DfT): Yes.

32. THE CHAIR: You're obviously reading our body language. We've all got our heads craned trying to work out what's what.

33. MR MOULD QC (DfT): Yes.

34. THE CHAIR: So we can be sure that we can all read and engage in the detail.

35. MR MOULD QC (DfT): I'll make sure we do that.

36. THE CHAIR: Thank you, Mr Mould.

37. MR WHITFIELD: Can I just ask for a clarification if we go back to what was page 45, the little squares with the black dots? They're not individual properties; they're locations that sound assessment was taken. So in the case where we have the cluster there, we can legitimately say it's effectively the whole of that hamlet is affected by noise at that level. Would that be right?

38. MR THORNELY-TAYLOR: That is right. There are cases where they are individual properties.

39. MR WHITFIELD: Yes.

40. MR THORNELY-TAYLOR: And there can be cases where the local topography is quite complex and one façade may be affected and another façade not. But it's absolutely right to say that the assessment locations are proxies for groups of dwellings around the location.

41. MR WHITFIELD: For the groups not necessarily within the square of the dots.

42. MR THORNELY-TAYLOR: Correct.

43. MR WHITFIELD: Yes, thank you.

44. MR MOULD QC (DfT): Where it's necessary to draw out that level of detail we can do that for you.

45. MR WHITFIELD: It will go to that level of detail?

46. MR MOULD QC (DfT): Yes.

47. MR THORNELY-TAYLOR: These colours, the red and yellow, if you get a good magnifying glass on the map with the grey and the pink contours you'll also see little properties coloured red if they do have noise changes of the magnitude shown in table five.

48. MR WHITFIELD: Right. Fine. Thank you.

49. MR THORNELY-TAYLOR: We can move on to the next slide. Where there is a railway running in tunnel there is a potential to hear the train underneath the ground. I won't say just like hearing the Underground in London because most of the Underground lines in London have very old fashioned rail support with rigid support between the rail and the tunnel invert and good transmission of sound into the soil and into houses above. Modern underground railways are built with resilient rail support and ground-borne noise levels are much lower. Nevertheless it's important to assess them, to predict them and assess them. And the same concepts of lowest observed adverse level and significant observed adverse effect level apply. They have numbers, which are maximum sound levels. These are internal sound levels because you only really hear a train in a tunnel below the ground inside.

50. There are also similar quantifications of vibration using the same criteria in terms of the vibration dose value. It's quite unusual with a modern railway for there to be any perceptible vibration except very close to a track and that means on the surface. You'd have to be only about 20 metres from a railway track to feel anything with your sense of touch or movement in the ground. We also carry this concept of observed adverse effect levels through into the assessment of construction noise. This table has a long history, very well established. It date right back to the Jubilee Line extension although we didn't have a noise policy statement back then but the framework of construction noise levels goes back that far.

51. As you've already heard, the control of construction noise is all done within a statutory process in the Control of Pollution Act and the well-known so-called section 61, which sets out a procedure for ultimately bringing about the best practical means of controlling construction noise. Briefly, I had mentioned yesterday the way we do fixed plant by comparing Leq levels with a background in terms of the 90th per cent level.

This is formalised in a British Standard, very well established, 4142 and the way that is applied by HS2 is summarised in that slide. That takes us to the end of the way in which government policy interprets the noise policy statement for England and its associated guidance.

52. As a consequence of that guidance there's a necessity in many cases to mitigate and minimise noise and I'll talk a little bit about how that is achieved. For operational noise there are three broad approaches. Clearly, train and track design are key and in the sound lab I talked a little bit about the sources that give rise to operational pass by noise. Some of it is the interaction between the wheels and the rails. Some of it is aerodynamic effects down at bogie level and the front of the train and the couplings between units of the train and also aerodynamic noise up at the current collection equipment known as the pantograph. The track also influences the generation of noise.

53. One of the consequences of using slab track is very high quality alignment of the rail so there is no contribution to sound vibration due to unevenness of the track, as can so often happen with ballasted track. Clearly reducing noise at the source like that is the most important, the best approach. But you can then move back and use noise barriers, either dedicated barrier fences or natural features or topographical features that are created during construction of the railway, earth bunds, sometimes with fence barriers on top of them.

54. We heard the effect of noise barriers in the sound lab. We listened to the effect of a three metre barrier and a five metre barrier in that first section of the simulation. Then when we moved to Hopton we were hearing the benefit of the combination of barriers that are designed into the railway at that location. If, after applying those two mitigation approaches we still have noise that necessitates avoidance of the effect, noise insulation at the receptor is available as the last stage in the process. As I explained there is a statutory noise insulation scheme which applies at fairly high noise levels but also if any dwelling is forecast to be above the significant observed adverse effect level the way we give effect to the policy guidance, which is to avoid noise about SOAEL, is to provide noise insulation at the receptor. We know from decisions the Secretary of State has made on other projects that he regards provision of noise insulation at the receptor as a way of implementing that policy requirement to avoid significant observed adverse effects.

55. MR MOULD QC (DfT): That would tend to be typically in the form of secondary glazing, wouldn't it?

56. MR THORNELY-TAYLOR: It will. Yes. But it extends beyond the extent of the statutory scheme because the HS2 policy is more generous in that respect. This slide just fleshes out what I was saying about the contributions of the different sources. From left to right is increasing speed and it shows what happens with the four main sources of noise an operating train emits. There is some noise which is independent of speed. It's equipment noise on the train. That's the horizontal dotted line. There's noise which is what you usually hear from the passage of a train, the effect of a steel wheel rolling on a steel rail. Even the best quality rail has tiny microscopic roughness to it, as do the best quality wheels. The effect of the rolling of a slightly rough wheel on a slightly rough rail is to excite those two components into radiating sound. That does go up with speed. That's the dotted line just below the solid one towards the top.

57. There are two other dotted lines there, which are important because they've got a much steeper rate of increase with rising speed. Those are both aerodynamic sources. The red one is aerodynamic noise caused by the front of the train, the bogies, the things I was talking about, the connection between the units of the train. The green one is important because it comes from the current collection pantograph that sticks up above the train. Although it's bottom of the pile, so to speak, apart from the horizontal line that's not speed dependent, it is important when you get very high noise barriers because the one thing that's still sticking up above the noise barrier is the top of the pantograph. That current collection bar that slides along the conductor on the overhead line equipment is rushing through the air at great speed and there's a certain amount of noise from that.

58. So in some circumstances all you really hear is the current collection bar rushing through the air when the rest of the train is shrouded by a barrier. As we get up towards the top of the speed range, 90% of our trains will be running at 330, the contribution of the aerodynamics sources starts to be very close to the contribution of the wheel/rail rolling noise. When you combine them using the decibel scale you get the solid line rising as speed increases we move to the right.

59. THE CHAIR: What if you had the electricity going through the rail rather than

through the pantograph?

60. MR THORNELY-TAYLOR: If you do that you have to have a third rail and a current collection shoe as you do with the original Eurostars, which used to run the Southern region, the Southern railway before the Channel Tunnel Rail Link was constructed. It's a very cumbersome engineering system. All high speed trains have overhead current collection.

61. THE CHAIR: Okay.

62. MR THORNELY-TAYLOR: And it is possible to reduce to that noise. In the next slide we can see how that is done. A completely untreated current collection pantograph, it's called a pantograph because you may remember there is a drafting device which is an angular set of wooden arms which enable you to trace a drawing and enlarge it. I don't think they've been used for many years but it looks a bit like that. That's why it's got that name. You can see how rough a system it is in the top left picture. You can imagine how taking all that equipment at 330 kilometres an hour through the air makes a lot of noise, simply air blowing over it. The bottom right picture shows what can be done both to put a fairing over the pantograph well, as that pocket is known with all that equipment in it. There's also been a lot of research into things you can do to the current collection bar to reduce the amount of aerodynamic noise which it creates. HS2 has been quite pessimistic in the assumptions it's made about the benefit that can be achieved by these methods of reducing pantograph noise. In reality the reduction will probably be better than has been assumed but the bottom right picture, which is a Shinkansen train, is an illustration of the current state of the art regarding that noise source.

63. Noise barriers, something we know a lot about. We had a bit of a discussion in sound lab. I explained that they have a sound-absorbent lining on the train side of the fence when it's a dedicated fence like that. This is a picture of what used to be called the Channel Tunnel Rail Link; we now call High Speed One and high noise barrier alongside the track. We will be looking at many cases in this process where that kind of barrier is assumed. The next slide will show us just the fundamentals of noise barriers, which is quite important. The thing which determines how effective they are--

64. MR WHITFIELD: Sorry, can I just clarify with the sound? This morning at the

laboratory you showed us the effect of two different heights of the sound barrier. Is it the taller one that will be the sort of basic one that we're talking about when we're talking about or is it the lower one that showed the top of the train, or does it depend where we are on the track?

65. MR THORNELY-TAYLOR: It does depend where we are on the track. There are a lot of cases where the taller height is the height that is assumed. Hopton is a complex combination of a little bit of noise barrier on top of a retaining wall and a dedicated fence noise barrier. Some of it is five-metres high above rail level. Some of it is six metres high but that is probably where there is a lot of mitigation it is the taller of the two that you'll probably find. If we go any higher than that the engineering consequences become severe. This room is six metres high. So a five metre high noise barrier is a lot of work, it's a lot of barrier. It's not really practicable to go much higher than that.

66. MR MOULD QC (DfT): When we show you these plans, which is an example of the salmon pink and the grey, you'll find that typically you'll see there's a blue linear notation along the line side and it has at various points the legend 'up to four metres' or 'up to six metres' that reflects the height of the barrier or embankment that is assumed for the purposes of the noise impact assessment. I draw that to your attention now because although I think it's fair to say the maximum height of noise fence barrier that you're likely to see assumed for this railway is five metres, you will find that the assumed height of the barrier may go up to as much as 15 metres. That reflects the fact that earth works are being assumed to have the effect of noise barrier mitigation. So people are confused by that, they think they're going to get a 15 metre high fence. They're not; it means that the railway will be in either a true or a false cutting, which has the effect of creating a barrier of that height, which is then assumed for the purposes of the noise impact assessment.

67. MR WHITFIELD: So just to clarify again that height is always measured from the rail track? So when we're saying 'assumed 15 metres' that's 15 metres above the rail track, irrespective of how you're looking at it from the farm road or whatever?

68. MR THORNELY-TAYLOR: That is correct. Yes, sir. And the geometry of this slide is the all-important, the critical calculation you do to work out how effective a

barrier is. There are three lines there. Two of them go from source, which is the ‘s’ at the left hand side to the top of the barrier down to ‘r’ the receiver. You work out the length of those two lines together. Then you look at the length of a line if you could do straight through the barrier, the straight one from ‘s’ to ‘r’ and the difference between those two lengths, the combined A + B – C.

69. THE CHAIR: I think we’re getting a bit too technical. Let’s move on. I don’t think this is a level of detail we need.

70. MR THORNELY-TAYLOR: Very well, we’ll move on.

71. THE CHAIR: All will understand, given the time constraints we’ve got.

72. MR THORNELY-TAYLOR: We’ll move on to something completely different, which is actually development of a point that was raised in the sound lab about the pressure wave that happens when two trains pass. A pressure wave also happens when a train enters a tunnel. And it is fairly important because when high speed trains first started to run nobody really thought much about this. As a train enters a tunnel, like a piston going into a tube, there’s a sharp rise in air pressure. As I was explaining at the beginning of my presentation changes in air pressure are what sound is. A sharp rise in air pressure is quite a big sound wave, in effect. It goes ahead of the train after it’s entered the tunnel and it will come out of the end of the tunnel way ahead of the train, much earlier than the train. In an untreated tunnel it will go out into the surrounding environment as a boom and cause complaints. It’s now well understood. It has this name micro pressure wave. The wave goes backwards and forwards within the tunnel. You hear it several times if you’re near the portal of an untreated tunnel.

73. In order to offset it, the tunnel portals will have something called a porous portal constructed. This will do two things. It means the actual point at which the train effectively enters the tunnel is through a much larger opening than the real entry to the actual tunnel. So the rise in pressure is much smaller. But this tapered entrance to the tunnel will have holes in it before you actually get under the ground to allow some of this pressure to escape so that when the train actually gets into the tunnel proper, that rise in pressure is nothing like as great when it is ultimately emitted from the exit tunnel portal. It doesn’t produce the boom in the environment. Petitioners read about this and they occasionally raise it, a concern about ‘sonic boom’; it will be designed out so it will

effectively be no worse than we get on High Speed One where it actually is not detectable.

74. MR MOULD QC (DfT): And then we have the familiar picture from Professor McNaughton. Then we can move on to the next.

75. MR WHITFIELD: Just on that porous tunnel, how restricted is the design because of the pressure waves? Is in essence there only one design that works?

76. MR THORNELY-TAYLOR: No there are many designs.

77. MR WHITFIELD: Is there an optimum design for minimising the boom and how much variation is there within that?

78. MR THORNELY-TAYLOR: The fundamentals enable you to have various ways of implementing them. Firstly, having a much larger entry to the tunnel, the tapered bit and the way you achieve the holes to allow the escape of air can be done in lots of ways. I could have shown you pictures of several very different looking porous portals. We will optimise the design both to get it to work well and look its best. But the fundamentals don't actually constrain it too severely so long as the basics are achieved. Operation of vibration, rather like sound, again mitigated by design of the train and its maintenance and in particular the track design. That effect I mentioned about slab track having a very good precision to the alignment of the head of the rail is particularly important in that it reduces vibration.

79. MR WIGGIN: Can I just ask one little question about the porous portal I was thinking about? When then train goes into the tunnel the design of the portal is different to when the train is coming out of the tunnel but the tunnel works both ways. So presumably when you're going in you blow the air away but when it's going the other way the directional channels must work the other way. Is that right?

80. MR THORNELY-TAYLOR: You've made a very perceptive point, sir, if I may say so. In an ideal world you would have only one direction.

81. MR WIGGIN: One direction, yes.

82. MR THORNELY-TAYLOR: But we have to design for possible bi-directional

working on occasions. So there will be a porous portal on both ends.

83. MR WIGGIN: And it will have the veins, essentially, that point them.

84. MR THORNELY-TAYLOR: It will work backwards at the exit end.

85. MR WIGGIN: Okay. Thank you.

86. MR THORNELY-TAYLOR: If we now move on to the topic of ground-borne noise, there's potential rumble that you would get if you took no mitigating measures. It's primarily a matter of track design and maintenance. In a moment we'll see some examples of resilient rail support which are the prime means of reducing ground-borne noise since the days of development of the London Underground. For example the Jubilee Line extension was the first underground railway to have resilient rail support, and, in particular, the realignment of the District and Circle Line as it goes through Portcullis House.

87. For a previous scheme I actually took people into a room in Portcullis House to listen to what they could not hear from the District Line running effectively through the building. That is because of resilient rail support. If Portcullis House had been built on the old District Line, not benefitting from the complete reconstruction of the Westminster Station that came about with the Jubilee Line, in Portcullis House you would have rumbling trains throughout the building. But thanks to resilient rail support I don't think there is anywhere in that entire building where you can hear a train pass. Yet, as you know from going onto the station platform, the trains are in a very intimate relationship with the building.

88. MR MARTIN: If I may say so, Mr Thornely-Taylor, you can feel the trains going through.

89. MR THORNELY-TAYLOR: I'm intrigued to hear that.

90. MR MARTIN: In some of the parts of Portcullis House you can feel the vibrations in the seat. I mean, you can't hear them.

91. MR THORNELY-TAYLOR: That's very interesting news.

92. MR WIGGIN: It may have been something else.

93. MR MARTIN: It may have been something else.

94. THE CHAIR: Do press on.

95. MR THORNELY-TAYLOR: Fortunately, no HS2 track runs through buildings like that. The next slide you've seen before; it's from Andrew McNaughton. We then move on to resilient rail support, which you've also seen, just showing how you get resilience into the track support system. Then we leave operational noise behind and move on to construction.

96. MR WIGGIN: Are the pads made of rubber?

97. MR THORNELY-TAYLOR: Yes.

98. MR WIGGIN: How long do they take before they wear out?

99. MR THORNELY-TAYLOR: 40 years.

100. MR WIGGIN: Right.

101. MR THORNELY-TAYLOR: Clearly in constructing a major scheme like this construction noise is potentially quite a big effect. A large effort has to be devoted to mitigating it. It's fortunate that construction plant has actually got a lot quieter over the years. We still use a British Standard, which dates from the 1980s with some fairly high noise levels listed in the back. But I'm sure Committee members have, like me, been to construction sites where it's actually quite remarkable how little is going on and what is going on is much quieter than it was formerly. There is this legal mechanism which can bring about the best practicable means to minimise noise which means not only procuring the quietest plant but also if there's a choice between methods of working there is a requirement to use the quieter method.

102. On the whole, given that we've had major infrastructure projects over the last few years, using the now well established regime for assessing, controlling and limiting construction noise, it has worked extremely well. There have been cases where people have been troubled by construction noise but considering the large number of very big projects there have been, this process that we now have does work very well. Local authorities buy into it. They operate their powers under section 61 extremely

effectively. The consequence is that we do get through to the end of major projects without significant effects. Noise insulation forms part of it and there are many cases where façades of dwellings are so close to sites that the solution has to be provision of sound insulation and alternative ventilation that goes with it.

103. There is also a trigger for temporary rehousing. Indeed on Crossrail, for example, one or two locations there has been a large amount of temporary rehousing because of construction noise effects. Whitechapel being an example. But it has, through working with communities it has proved to be a successful way of getting the projects completed without severe impacts on the people affected.

104. MR MOULD QC (DfT): So in each area the environmental health officer has a crucial role to play in regulating these matters of construction noise.

105. MR THORNELY-TAYLOR: Everything I've said about noise in construction applies to vibration. It's a little bit different in that there's no equivalent to noise insulation. You can't put any secondary glazing in to reduce vibration so it's rather more dependent on monitoring and management and choice of methods of working, avoiding percussive methods where you can use non percussive approaches. At the moment there is a big project going on in London which is the upgrade of Bank station and a huge amount of effort has gone in to methods of working to avoid vibration and ground-borne noise effects from that. The contractor is most enlightened and using methods which ordinarily would cause quite severe effects on the sensitive buildings above the works but is managing to get the process through by choice of methods of working primarily. To finish off with, there's just a slide listing the information papers, which are available on the web and they merely set out effectively the approaches which I've outlined in my presentation. Thank you.

106. MR MOULD QC (DfT): Might I just make the link back to one of the topics I covered in my opening statement? These information papers include a series of precisely worded commitments on the design, operation and maintenance of the railway, which are founded upon the various noise levels and mitigation techniques that Mr Thornely-Taylor has explained to you. And which, in turn, are recorded in the register of undertaking and assurances. Therefore form part of the environmental minimum requirements which Mr Miller explained to you yesterday. That's the link through to

the control of environmental impacts that we've sought to outline to you in the course of these presentations.

107. MR THORNELY-TAYLOR: Thank you very much.

108. THE CHAIR: Mr Thornely-Taylor, not sure it's a direct noise question but I've got a niggle about construction hours because information paper D53.1 gives a very clear view eight o'clock to six o'clock, Monday to Friday and then Saturday. I was unsure why there was work on Saturday. Then it goes on in the next two pages with lots of 'but this could happen' or 'that could happen' or 'this is an exception' and 'that's an exception.' Then I look at page 48 of this from the noise perspective to give an indication. I just haven't got a feel for when the down time for everyone around the construction will be, the quiet time. Clearly in an ideal world, being very grossly simplistic it would be kind of a 9-5 working then everything would be beautiful and silent. I know that's unrealistic. But it does feel that there's kind of quite a porous timeline beyond the simplicity of 3.1.

109. MR MOULD QC (DfT): The position in a nutshell is that those core working hours that you've outlined are expected to be the norm for HS2 construction sites. The one exception to that will be underground working. Tunnel working is 24 hours but at surface working work sites the norm is those core working hours. There will be cases where, for reasons of for example to seek to minimise the need for possessions, for disruption of the existing railway line where we have works which interact with those works or where it's necessary to bring in exceptional loads, matters such as that.

110. The range of matters you've seen described in that information paper where it will be necessary to undertake work outside those hours from time to time, those cases will have to be put to the environmental health officer for the area in question under the Control of Pollution Act licencing regime that you've just had outlined to you. HS2 will have to secure the EHO's licence for those works outside core working hours. So the position is, it is genuinely correct to say that the core working hours are as stated. There is a strict control over activities at surface that are proposed, for which a licence is sought outside those hours. I can ask as we go through that my witnesses elaborate on that, particularly where there are locations where we can already anticipate there may be a need for working beyond those hours.

111. But that is the established position. It is does reflect the experience that those constructing Crossrail and indeed the Channel Tunnel Rail Link have. I think I'm right in saying that the approach set out in that information paper reflects the practice that has been adopted on those earlier schemes.

112. THE CHAIR: Thank you for that. We'll understand a bit more about it as we go on. Thank you very much, Mr Mould. Thank you very much for your time.

113. MR MOULD QC (DfT): Now, Mr Smart is going to make a presentation on tunnels.

114. THE CHAIR: I propose to take a five-minute comfort break in between the next two presentations.

115. MR MOULD QC (DfT): Thank you.

116. THE CHAIR: And Mr Wiggin needs to leave for a longstanding prior engagement at 35-40 minutes before the end. So no slur is intended.

117. MR MOULD QC (DfT): And Mr Smart will introduce himself in the usual way.

Presentation by Mr Smart

118. MR SMART: Good afternoon, my name is Tim Smart. I'm chief engineer for High Speed Two. As you may be aware, I was also the engineering witness on Phase One of High Speed Two in this House and the other place. So if I can go to the first slide. I thought it would be helpful if I explained why we tunnel. And indeed, that comes down to three main reasons why we would be in a tunnel. Most obviously of course when the terrain is too steep and we can't traverse it without unacceptable gradients we would potentially need to go into tunnel. That is essentially where we are for the two tunnels on the Phase 2A build. There also can be issues with connectivity if you put a railway line let's say through a village and you actually sever the village. You would maintain the roads but there could be potentially unacceptable severance issues other than maintaining the roads. That's another area where one would look at the potential use for a tunnel. Most obviously where surface disruption is severe, which is why most new metros are in tunnel because otherwise when you're in cities and big urban developments the disruption on the surface would be unacceptable. And of

course it the renders tunnelling the most cost-effective construction solution because it is much more cost effective to tunnel than it is to buy a lot of properties.

119. So on Phase 2A we have to fairly short tunnels, which I will just go to the next slide. I think the Committee are very familiar with this ground from being on the route visit. As the route passes going to the north under the A53 Newcastle Road we get to Whitmore and it goes into 240 metre cover tunnel, which I'll come to later. Then a twin bore tunnel under Whitmore Heath for about 690 metres at a maximum depth of around 50 metres. The northern portal is just where the route crosses what is Snape Hall Road but I'll come on to that later on another slide. On leaving Whitmore then the route is in a 580 metre retained cut at Whitmore Wood, which again I think you'll be familiar with from walking past it. The cutting is deepest at about 13 metres. Then as we move north just over four kilometres we come to the southern portal of what is the Madeley tunnel. The Madeley tunnel is a 680 metre twin bore tunnel as the route passes under Bar Hill with a maximum depth of around 38 metres.

120. MR MARTIN: Sorry, you said it's a what tunnel?

121. MR SMART: Twin bore tunnel.

122. MR MARTIN: Twin bore tunnel.

123. MR SMART: Yes. So this is briefly what I'm going to go through in my agenda, having set the scene. Some issues around construction and the techniques to build tunnels. Operational aspects of what happens once the tunnel is in operation and running trains and then of course implications for costs.

124. THE CHAIR: Actually Mr Smart, maybe at the end to talk as well as costs of what HS2 are proposing, what the costs would be and the implications and considerations of tunnelling all the way through which is an issue we'll be looking at early on.

125. MR SMART: Yes, certainly.

126. THE CHAIR: Perhaps tack that onto the end. I don't want to dominate your discussions but just putting you on notice that we'll perhaps tease out some awkward questions around costings and the issues just to get them on the record as much as you

can.

127. MR SMART: Yes, and I think that will come out on some of my slides, sir.

128. THE CHAIR: Thank you.

129. MR SMART: So the three main construction techniques we use are bore tunnels, which is where the tunnel boring machines come in. Machines are usually used for long and deep tunnels or where surface access is not realistically possible. Also where the ground or groundwork conditions can be poor and unacceptable ground. The tunnel is formed of precast concrete rings called segments. Where the tunnels are shallow and there is good access from the surface it is possible to use a cut and cover tunnelling technique, which is basically using deep civil engineering construction techniques. As I say it is where access from the surface is good and I will come to that. Then finally there is what is known as a mined or sprayed-concrete tunnel. Now this is where you excavate with not a tunnel boring machine but with normal type back actors or road headers as they are termed. For that you need the ground to stand up for sufficient time before you can spray on a concrete lining to support it. So the ground conditions need to be quite good. They also need to not have problems with high water pressure. We also use this technique in the cross passages and I'll come to what cross passages are and what they're for later on in my presentation. But we will be using SCL on Phase 2A for the cross passages as envisaged.

130. MRS MURRAY: Can I just ask for the cut and cover tunnels clearly it would have an impact on the surrounding area so if you wanted to protect something on the surface you clearly couldn't use that method.

131. MR SMART: Correct. Correct, that's right. I'll come on to that in my slide but I'll show you how it would affect surrounding areas. Therefore you do end up with an area where you have to have nothing on the surface.

132. MR MOULD QC (DfT): SCO is sprayed concrete lining.

133. MR SMART: Yes. Sorry, I forgot to say that. So bore tunnels, I'll try to avoid getting too technical with this but this does impinge on costs so if you allow me to just explain what's happening here. This is what is known as an earth pressure balance

machine. Basically this relies on forcing pressure back onto the ground that is trying to come in on you, to cave in, if I can use that term. So as the cutter head, which you can see, turns, soil comes in to what is known as the excavation chamber and is held there in a pressure by the machine. The material, the soil, the excavated material, is removed from that excavation chamber via the Archimedes screw, which you can see in a controlled way on to a conveyer and out the back of the machine.

134. This is important for two aspects; one is it affects the speed of tunnelling and two it affects settlement. Because if you hold the ground you build the ring, which is shown back here. It will be this area. What's known as the tail skin there, you're injecting ground to take up the slack of the ground. Basically you're making sure that settlement is minimised and if the ground is not very good and it's forcing into the machine at a rate that's quite high, you have to have more pressure from the machine and the machine is in what is known as 'closed mode'. In other words, it's having to work hard to resist water pressure and the ground coming in. That would be in things such as silts and sands. Now when the tunnelling machine is in good ground, in London especially we have good old London clay which is probably the most tunnelled medium in the world and it's generally a good medium to tunnel in because the clay stands up and it doesn't transmit water.

135. When you're in those sorts of soils you could have the machine in what is known as 'closed mode' where it is not having to counterbalance the ground coming in and is therefore open. You can almost just turn the cutter heard and take the clay away in a much more less controlled way because settlement is not so severe. The material goes through the machine into a conveyer and then right back to what is the tunnel dry site. They don't have to be conveyers. You can use dump trucks to take the material away but that's less common and you do need much bigger tunnels to use dump trucks. I'll go to the next slide.

136. MR WIGGIN: Just before we leave that one has does the segment get put in?

137. MR SMART: The segment comes in on generally a loco, so you would have the logistics to the machine is not just the conveyers excavating material away. There are rails that come in to the front of the machine. If we go to the next slide you can see there's a lot of logistical back up at the back of the machine. So what has to come in to

form the ring is the precast segments, which I'll show you a slide of and they come in on what are locos. If we go back a slide, there's the segment erector which is shown and they're loaded on and the segment erector puts up the segments to form the ring, the tunnel ring. Then there's grout to make sure that minimises the settlement. Then you push the machine forward and do another ring.

138. MR WIGGIN: And the grout is outside the segment?

139. MR SMART: It goes between, on here it says tail skin, so it goes between the ring that's erected and the tail skin of the machine. There's a small annulus around the ring caused by that tail skin.

140. MR WIGGIN: So that grout is concrete is it?

141. MR SMART: Yes, so as you move the machine forward you're extruding grout into the ring so that if the machine starts getting ahead of the ring you're going to have a problem.

142. MR WIGGIN: Yes. And how many pieces of segment?

143. MR SMART: It depends on the type of tunnel but typically about nine.

144. MR WIGGIN: About nine?

145. MR SMART: Yes, seven to nine to form that. It will be bolted in our case. You can in some soils like clay you can use an expanded wedge block system where basically you expand the tunnel but we would have ours as a bolted tunnel.

146. MR WIGGIN: And so that's to be done manually, is it?

147. MR SMART: Yes, that's done manually. The erection is done by actual ring erector, which is a bit like a back actor but then the miners usually have power drills and just screw the bolts together. That holds the whole thing. Although when the ring is in place the bolts don't really do too much because the pressure of the ground.

148. MR WIGGIN: Stops it twisting?

149. MR SMART: Yes, and there's a stress redistribution.

150. MR WIGGIN: Excellent. I love this.

151. MR SMART: Right. That's really just to give you an idea of what a tunnelling machine looks like. I'm sure you may have seen them. That actually is an HS1 Kawasaki machine I think. Ours will be slightly larger. That one is a 7.15 internal diameter tunnel but because of our speed, and you've heard about aerodynamic pressures, our tunnels are slightly bigger so ours are 8.8 in internal diameter for a 320 kilometre per hour tunnel, which is what the tunnels are at Madeley and Whitmore.

152. Moving on, Mr Wiggin mentioned segments and there they are in a segment yard. They weigh about seven tonnes. So they're typically 1.5 metres long and a metre wide and about 450 in depth reinforced with fibres because that's good for fire resistance. Sometimes they do have steel inside them, steel bar, if they're going to take high pressures but generally now modern technology is to use fibre reinforcement, which is little bits of steel that look rather like staples. Onto the next slide, which is the tunnel at Whitmore Heath. This is the construction lay out. I might just move up one if I may.

153. MR WIGGIN: It is really just to ask you about how you do the reinforcing. Is it like fibreglass, where you just include them in the mix?

154. MR SMART: You do.

155. MR WIGGIN: Yes.

156. MR SMART: But the fibres… It's called a dosage rate, and it's usually a mix of polypropylene, steel and you dose it into the concrete.

157. MR WIGGIN: So, it's lots of little fibres all holding it together.

158. MR SMART: Yes. As I say, they look rather like staples, the steel ones. But when you're at high pressures, you would use rebar, the matting, the steel matting.

159. MR WIGGIN: Okay.

160. MR SMART: So, this is the tunnel at Whitmore Heath and, as you can see, this is the construction layout. And you will notice that we have facilities at either end for tunnel portal buildings – and I'll come onto that, as to what they are.

161. And we show one at either end. This is potentially for when we get further into the design. On tunnels of this length we might only need one, but at this stage we cannot be sure, because we haven't done a sufficient amount on the design.

162. And it shows you the site layout for this. Because the drives are fairly short, we do not need a major tunnel drive site, and it is not anticipated that we would be casting the tunnel segments on site. Because of the length of the tunnel, it is probably easier to buy pre cast segments and import them rather than set up a whole segment manufacturing yard for a tunnel of this sort of length, 690 metres.

163. MR WIGGIN: How long will it take you to build the tunnel?

164. MR SMART: Well, at this length, if you're averaging 90 metres a week, it's pretty quick. It's a matter of sort of… That's a hard average, so you'd have to take a look at setting up the machine and everything, but you would be able to do this sort of tunnelling within, by the time you've set the machine up, a year to 18 months.

165. MR WIGGIN: I didn't hear that, sorry.

166. MR SMART: About a year to 18 months. So, if we go to the next slide, I think that should be the operational configuration. That's the final configuration at Whitmore Heath. Mr Thornely-Taylor has talked about porous portals, so I won't dwell on that, but we will have the porous portal lengths, which are currently envisaged to be 150 metres – but during detailed design we would hope to reduce that.

167. And there are the tunnel portal buildings. There are requirements for safety, which I will come onto, with regard to those portals. But also they are the buildings which would house transformers and switch gear for things like fans, which are sited at the tunnel portals – and I will explain in a moment what those fans do – and also pumps, lighting, emergency communications and everything else that you would need in a tunnel.

168. MR WHITFIELD: Presumably, when you are talking about it being the two tunnel option here, it's just one tunnelling machine you would use for both.

169. MR SMART: Well, it would depend.

170. MR WHITFIELD: You would dig both tunnels at the same time, would you?

171. MR SMART: It very much depends on programme. So, if you have got a more relaxed programme, then you can use one tunnelling machine. You take it through and recover all those parts that you can. Sometimes the cutter head can be a bit worn, but on the length of this tunnel you could probably re use that.

172. But if the programme is tight, you might have two machines doing the two bores; you might even have four. There are instances sometimes where you might even tunnel from both ends. It all depends on the programme, because that comes by adding cost and reducing time. So, there is a balance to be struck between the number of machines and the length of the drive.

173. Because these two tunnels are both fairly modest or, I would say, of short length, I'd envisage that there'd be two machines that would do the four bores, effectively.

174. MR WHITFIELD: Would you envisage that number changing in another option, if it was a single tunnel? Would you still need two machines?

175. MR SMART: I don't believe our programme will be so tight, sir, that we would need to go to four. I wouldn't envisage more than two.

176. If we go to the next slide, it's the same sort of story at Madeley. It's a tunnel of similar length and it has similar provisions for the permanent operational case. So, I think it's best if we move on and I'll explain more about what you need for safety, which is why you need the tunnel portal buildings.

177. I'm now coming to cut and cover tunnels.

178. MR WHITFIELD: Sorry, just a silly question. You're boring two tunnels. Do you both go the same way? Is one coming one way and one going the other way?

179. MR SMART: You would normally go from the same direction, because you want the logistics of taking in the segments, taking in the grout, taking in personnel from one end, but you would lag them. If you run the two tunnels together, you get issues with settlement.

180. So you would probably have a lag of a number of hundreds of metres, but you

would run in the same direction with one drive site, get to the end and then ideally you take the tunnel machine out at the other end.

181. For the Channel Tunnel it was too expensive, so they buried it inside. But usually for this sort of tunnel you would take it out.

182. MR WHITFIELD: Yes.

183. MR SMART: So you asked a question on cut and cover methodology. This is the open cut methodology. Now, this does take land, as you pointed out, Ms Murray, and what this slide has not got is, when you dig out the ground, you have got to have a spoil pile somewhere. So, first of all you would take the topsoil off, which is a valuable resource – and that needs to be stored – and then there would need to be a storage area for the ground that you take out.

184. The other thing is that, depending on the quality of the ground, those side slopes could be slacker and, therefore, they would take up more space. So, typically we would work on one on two, i.e. two metres going up, one metre going along. But it depends on the ground. So, you would excavate; you would then build the base; and you then build the tunnel in reinforced concrete with all the normal formwork and shuttering. You would build those cells.

185. Now, there are reasons why we have two cells like that and we have a central wall. One is because of the aerodynamic effects of two trains approaching at nearly 700 kilometres per hour in close proximity, and also because of safety reasons, which I will come to. But you then basically back fill the cut and cover tunnel.

186. So, if we go to the next slide, if there are constraints on the width of a cut and cover tunnel, it is possible to use what is effectively known as a top down technique, where you form two reinforced concrete sidewalls either by a technique which is known as diaphragm walling.

187. I don't want to get to technical, but it's basically like a solid wall, a couple of metres wide and a metre thick, that goes down in sections, in piles. You could also use piles close together, but you've got to build that structural supporting wall. And then you excavate the soil in between and you prop to keep the walls from coming in, so you

support that structurally. And then you build the tunnel in that way and you back fill.

188. Although it is much more efficient on space, it is a more expensive technique. There are some quite interesting structural conundrums you get into with supporting it if you get into areas with plunge stanchions and things. This is where you would be if you were in a potentially more urban environment and you didn't have the space to do an open cut.

189. I should have mentioned on the previous slide that, when you are doing an open cut, you wouldn't open the full length of the cut and cover tunnel. You would go in bays with a maximum of 200 metres and maybe less. You would excavate, cost the cell and then put the soil over the top and progressively go down the cut and cover tunnel. To give you an idea of size, each of the cells we need will be about seven metres by seven metres to have the free air for aerodynamic comfort, for all the comfort you would need in a tunnel.

190. So, if we go to the next slide, this actually shows a HS1 cut and cover tunnel at Boxley. This is a before and after slide. You can see this was in a rural environment, but what it does show is, if you look at the trees on the left of the slide, they had to be kept much the same as I think you saw at Whitmore when we out on the site. Therefore, there is a retained cut along there. Although it was an open cutting, it wasn't over that section. So you can combine the two methods of cut and cover tunnel, should you need to.

191. If we can go to the next slide, settlement, as I previously explained with the rather lengthy explanation of the pressure balance machine, settlement is something which is becoming much less of a problem now with the advanced in machines. Certainly in the instances of the tunnel we have on Phase 2A at Whitmore and Madeley, we don't really have issues with settlement – because we can control them with the machines.

192. I won't go into the detail of what the provisions are to make sure people are protected in case of settlement, because that is in paper C14, which I believe, is in your bundle. But, basically, we do an assessment. If the parameters are acceptable, that there is no risk of damage, anything that's slight, which is basically repainting, then we don't take any further action. If there were some decorative cracks or repainting that had to be done, that would be done at the cost of the project.

193. Now, Chair, you mentioned 24 hour working. Tunnelling is 24 hours, because you don't want the ground to relax, because you want to keep that dynamic movement and grouting. If you stop, then you're liable to increase the amount of settlement. It's called volume loss. That's the relationship between the trough that you get at –

194. THE CHAIR: Sorry, just to be clear, are you talking about the surface?

195. MR SMART: Yes. Because it does come out to the surface. I'll explain a little bit about that when we get onto that slide.

196. THE CHAIR: Fair point.

197. MR SMART: So, now we're onto noise from the tunnel drive sites. I think Mr Thornely-Taylor did cover this a little bit, but obviously we are subject to all the same restrictions and procedure of the code of construction practice. Actually, tunnel sites are no worse than any other big civil engineering site. I would actually go as far as to say they might actually be better, because the actual doing end of what is happening is in the ground.

198. What you have in the surface is some conveyors coming out with excavated material, and you can mitigate the noise for that quite effectively by putting baffles on the conveyers. Of course, the machine is not travelling at a vast rate. Tunnel sites in London have lots of piling rigs and lots of diaphragm walling machines, which are up in the air. Therefore, although it's 24 hours, I would say it's no worse and arguably better than a normal construction site.

199. MR WIGGIN: Do the trucks keep going at night, then, taking the spoil away?

200. MR SMART: Well, the trucks don't, no, because you have to make sure you have sufficient storage for, say, five days.

201. MR WIGGIN: Right.

202. MR SMART: Otherwise the machine could become what we term muck bound, and you can't advance any more because you've to nowhere to take the excavated material. So, the HGVs that will take away the excavated material will not necessarily be 24 hours, but you would want to keep the machine going.

203. Having said that, the reason we work on hard average drive rates and not fastest drive rates is because the machine has to have downtime for maintenance. Because although we don't really want to stop the machine, you have to at certain times to intervene. The worst case is that there's a machine failure, which you don't want – but it does happen.

204. MR WIGGIN: Okay.

205. MR SMART: So, going onto the next slide, I think, as Mr Thornely-Taylor already said, when a tunnelling machine is deep in the ground you might perceive a slight a slight rumbling as the machine passes, but it would be in a matter of days and, therefore, I'm certainly unaware, having done a fair bit of tunnelling, of it ever causing a problem to any residents etc.

206. Now, I'll come to the minimum safety requirements. Now, this is about tunnels of less than 1 kilometre, because, as tunnels get longer, Chair, as you've already pointed out, they start to accumulate things, which do translate to costs – and I will come on to that later in the presentation.

207. So, these are the minimum safety requirements that we would need for the tunnels of around 600-700 metres that we have on the Hybrid Bill scheme. You need a place of safety every 500 metres. That means if people get off the train in the event of a fire, they can be safe within 500 metres. That is where the cross passage comes in, and I'll come to that, because the tunnels are longer than 500 metres. On these two tunnels, we would have one cross passage – and I'll explain what I mean by that in a minute.

208. And you also need, as you saw in the layout of the tunnels, an area for firefighting where you can get water in at 800 litres per minute for at least two hours, so you've got to have water mains in the tunnels as well as electricity.

209. That is about it for a one-kilometre tunnel in terms of the minimum safety requirements. We do more than that, which I will now explain on the next slide.

210. MR WHITFIELD: Sorry, just on that point, they're 400 metre trains. With the two tunnel option, it's actually going to be much closer just to leave the tunnel. You've got passengers going all over the shop in the tunnel, haven't you, effectively?

211. MR SMART: Yes, you have. Can I just explain that, sir, on the next slide?

212. MR WHITFIELD: Yes.

213. MR SMART: Because it's a very good point. With tunnels of such short length, you would literally walk out of the portal. However, it could be that there was some very unusual adverse scenario where you might be able to not get out of one portal, so we would put at least one cross passage into these, one in each tunnel.

214. This shows you an HS1 type cross passage. They're about 3.5 metres in diameter. The way in which you evacuate is this. In the event of a fire when the train can't get out of the tunnel – and I'll come back to that – you go onto the walkway, along the walkway, through the cross passage and into the adjacent tunnel. Of course, the trains are stopped. What we have are fans on a short tunnel at the portal, which will maintain a positive air pressure in the non-incident tunnel so that when you open the cross passage doors you don't let the smoke in. And people can then safely go into that relative place of safety, where they wait until a rescue train comes to get them.

215. Now, the chances of that happening are a very, very low probability, because the trains would drive out of a tunnel. Therefore, I would venture to suggest that on tunnels of the length we have in this Hybrid Bill it will never happen. But because fire safety is so important, we would still build this facility in the very unlikely event we needed it.

216. When you get into longer tunnels, this becomes much more of an important consideration, because you could have a train that does stop. But even then modern rolling stock is fire rated. Even if you did get a fire on a section of the train, you can move passengers to another carriage and seal it and you can go for quite some time. In fact, the rolling stock which is known as class B, which is passenger trains, have to be fit to go 20 minutes in the event of a fire – and that would get us out of any tunnel we've got in Phase One or Phase Two anywhere. But you nevertheless have to legislate for the unforeseen.

217. MR WHITFIELD: Sorry, can I just clarify? The place of safety is actually the other tunnel.

218. MR SMART: It is.

219. MR WHITFIELD: It's not the cross section. That's merely a route to the place of safety.

220. MR SMART: Correct.

221. MR WHITFIELD: Right.

222. MR SMART: We call it the non-incident tunnel, which would be an empty tunnel.

223. MR MARTIN: And this picture with the trains in the tunnel is actually a fairly scale sort of drawing, so there is a substantial amount of space between the train and the tunnel.

224. MR SMART: Yes, it'll be about an 800-millimetre walkway, and you go right along the walkway. There is a handrail, but not of course on the walkway edge because it couldn't be off the train, but it is on the wall.

225. And of course part of the safety case is to look at what actually you need in terms of on train staff to properly manage this – even though it's a very, very low probability.

226. MR WIGGIN: If the passengers are standing on the concrete and a train does go past, what happens to you? How bad is it for you if it goes past at 260 kilometres per hour?

227. MR SMART: It couldn't because of the failsafe in the ATO system. Also, if you had a very long tunnel, you would have to have vent shafts and that also forms a signalling section. You can only have one train between signalling sections, so everything would shut down. That is just something that couldn't happen.

228. If it did happen, it would be quite a severe rush of wind, but it's designed so that that cannot happen under our safety system.

229. MR WIGGIN: It wouldn't kill you.

230. MR SMART: It wouldn't kill you, but I wouldn't want to be standing there if it did, because it might throw you against quite hard against the tunnel edge.

231. MR WIGGIN: Okay, thank you.

232. MR WHITFIELD: The James Bond scenario.

233. MR SMART: This is actually an HS1 tunnel. You can see that's a cross passage there. Not with the doors, because you have to have doors, of course, to stop the smoke getting in. That's before the doors are fitted and that shows the walkway – just to give you some idea of the scale or what it would be like.

234. Then, onto the next slide, I won't dwell on this. I was going to talk about the vibration in tunnels, which isn't a problem because you can mitigate it with the resilient trackform, which Mr Thornely-Taylor has already covered.

235. MR WHITFIELD: Is it the same track for the entire length of the track, using this resilient track? Is it effectively the same?

236. MR SMART: Yes, it would be. That's a particular form of how you can do it. There are many other ways. With track slabs, we can probably use the track slab we would use on the open sections but just put it on a concrete base.

237. MR WHITFIELD: You would put it on a base and just…

238. MR SMART: Yes, there are a number of ways of doing it. Generally, it is not a problem when you are deep. It is only as you start to come up at the portals do you start to experience any problems.

239. So, we come onto costs. I think, Chair, this is where you wanted me to explain a little bit. The thing about tunnelling is that it does have a very high fixed cost, because you have to buy the tunnelling machines, which typically come in at £15-25 million apiece. If you have two, you are already up at £30-50 million before you have even started to bore.

240. You need the backup logistics, which I have talked about, which is conveyors – or, indeed, it could be dump trucks, but I would say that's unlikely in our case – and you also need the little locomotives and light railway, which you use to run in materials and segments.

241. So, all of that has to be in place, plus you need a power supply. TBMs need something in the order of 10 megawatts per machine, so you've got to get a fairly decent

electricity supply; you can't just plug it in with a 13 amp plug. That would require transformers, and you've got to get a decent and resilient supply on the electrical network with National Grid. And you've got lots of other mechanical and electrical systems, pumps – and of course ventilation, which is vitally important for the operation. You've got to get fresh air into the tunnel and keep it cool for when they're working.

242. So, all of that would be a fixed cost. Some tunnelling techniques, which I haven't gone into here because we probably won't use them on Phase 2A, such as throwing machines, might have what is known as a fairy big recycling plant for certain materials you use in the tunnelling, but we won't have that here.

243. You then go into the linear costs, which is quite simply the cost of the labour and any ground treatment that you're doing. You're doing more or less grouting around the rings. It's really just the cost of the operatives who are there per week or per day and the materials, e.g. the segments. And there is a cost of machine in terms of maintenance and everything.

244. So, that is the linear costs. And then you get what I call incremental costs. As soon as you start to make the tunnel longer, the costs start to step up. For example, I've said on a one kilometre tunnel, we would only need one cross passage. If we were up to a 15 kilometre tunnel, we would need about 18 cross passages, and they come at about £1 million each for a cross passage.

245. Also, as soon as you go longer than about one kilometre, you need a vent shaft, and you might need more than one. A vent shaft has the cost of the physical shaft itself. You've got to sink the physical shaft. They're typically 28-30 metres in diameter. They would need at least two or three fans in the head house, which of course blows smoke away from passengers who are escaping in an incident tunnel and keep the pressure in the non-incident tunnel so smoke doesn't go in. We still need them on portals on short tunnels, but they are not such a heavy duty or large fun. In vent shafts you need those fans.

246. The point of the vent shaft is not for passengers to escape up. They would go onto the walkway, as I explained, and go on a rescue train. The point of the vent shaft is for the emergency services to get to the train that is potentially on fire. Now, if there were no passengers there, it's a bit of a moot point as to how much the emergency services

would thank you in order to get all their fire handling and breathing gear right down a tunnel, but nevertheless they can't go more than about one kilometres with that or it's impractical. So, that sets a practical limit to where the vent shafts have to be: as I say, about 3-3.5 kilometres.

247. MRS MURRAY: Can I just ask something? I understand all that, but could you give us some idea as to the actual digging cost? Is it disproportionate, because you've already got the machinery there, to continue straight through rather than doing two separate tunnels?

248. MR SMART: It's not disproportionate. In other words, if you've got a machine in the ground, it can be more cost effective to go further with it, because clearly you're getting better utilisation out of the plants.

249. MRS MURRAY: Yes.

250. MR SMART: However, it doesn't come free, because if you do the sort of payback analysis you can't just exclude the cost of the tunnelling machine for going the extra length; it still needs to be included.

251. But it does include the linear cost, because the further you go, you may need more electrical power; you will certainly need intermediate conveyor handling. The costs do get more. What you do have is the cost per metre of the machine is spread over however far. That's the advantage. But, of course, to counter that, you've got vent shafts at three kilometres at beyond – and obviously more cross passages. And the linear costs are still significant; they're not nothing.

252. But I think the point you highlighted is what I call the machine utilisation costs. They are spread. When you look at it on a per metre basis, of course then it looks more economic.

253. MR MOULD QC (DfT): You've got a combination of those factors on the next slide.

254. MR SMART: Yes, if we go to the next slide, if you look at how the costs go over length, this is very schematic. It is idealised; it is to demonstrate the point.

255. But you have a step up. Where that first step up comes, that would be about the three kilometres point where you then introduce a vent shaft and you need all the mechanical and electrical plant that goes with that. You need stairwells; you need lifts. The stairwells have to be air pressurised to keep the smoke out, so the fire brigade can go down.

256. Of course, as you go further, you're introducing more cross passages between the two tunnels. They're every 500 metres maximum, but actually some of our cross passages are less than 500; they are actually at 350 metres. Then of course yore introducing more vent shafts. And because you're going on a longer tunnel, you need to have longer rail for your locomotives; you need to have more power for the locomotives; you've got to have more ventilation equipment. All of those things start to increase.

257. MRS MURRAY: And would that cost perhaps be reduced if you started at each end, with two machines starting at each end?

258. MR SMART: Well, the time cost would be reduced – and that's often why you do it, because the cost of the scheme coming online and the public benefit is realised much, much sooner. However, instead of having £50 million for two machines, you're now looking at £100 million.

259. You've got to really look at the benefits you get by introducing two more machines. Unless you have to do it, because the ground is so aggressive that you would be concerned that one machine could only go so far without shaking itself to pieces, you'd have to re look at the economics of the balance between the length of drive and the number of machines.

260. On the Jubilee Line, we had a very short section between Southwark and London Bridge, and we had four machines on it because of the tightness of the programme. It really does depend on the balance of the programme. This is the length of time to build the tunnel compared to the fixed costs of the set up.

261. As I said earlier, I would see the balance on the tunnelling we've got here would be a two machine max, because I don't think we would need more than that to achieve an acceptable programme – assuming, of course, we don't get into problems with

machines breaking down, which you get in incredibly bad ground.

262. MR WHITFIELD: Am I right to say that the planning is still wide enough open to go for two or four? You're not within a constraint of timescale yet where that is becoming a crucial decision.

263. MR SMART: We've got some time constraints, because we're obviously tying to open this section of the line as coincident with Phase One as we can.

264. MR WHITFIELD: Yes.

265. MR SMART: But, from looking at what we anticipate our construction programme to be, we think that two machines would be the maximum you would need.

266. MR WHITFIELD: Can I ask whether or not you've considered something? Irrespective of which scheme is used for this, will the tunnelling machines be the same tunnelling machines as are used for the next section going under Crewe? Would that have to be a completely different set?

267. MR SMART: Potentially, you could use these machines. Potentially, you could. But it's often not quite as simple as that. It's not like buying a second hand car.

268. MR WHITFIELD: Yes.

269. MR SMART: Quite often the constituent parts of the machine are a bit worn out, but you could certainly salvage some key parts.

270. Often machine manufacturers – and there are not many of them left in the world now: they are either Chinese or German – will give you an advanced payback price, which the contractors will negotiate, which says, 'At the end of this, all things being equal, I'll sell you the machine for £25 million but I'll give you £4 million back.' That will be taken into account in the tunnel costing.

271. MR WHITFIELD: But in reality it's a very small proportion of what it costs.

272. MR SMART: It is really, yes. What would be more potentially useful would be logistics: if you could re-use the locomotives and the rail, yes.

273. MR WHITFIELD: Right, yes.

274. MR MARTIN: And it's not possible to lay the final track. You have to have a temporary track for carrying materials. You cannot lay the final track.

275. MR SMART: Yes, yes.

276. MR WHITFIELD: You could put the boring machine on track.

277. MR SMART: If you did construe a way to do it, it would make the tunnel boring so slow that the cost would be…

278. MR MARTIN: Yes, right.

279. MR SMART: If only we could get a machine that actually did do that.

280. The other thing I should point out on cost – I think we had a discussion out on the route – is that what you do with the material that comes out of the tunnel is something incredibly important to the cost of tunnels. If I could highlight the HS1 tunnel at Stratford, our drive site was Stratford with a big box, and all the material – except for one tunnel, which was under the Thames – came out. We were able to do a land raise at Stratford. Therefore, we did not have the costs of exporting it and taking it a distance.

281. As soon as you have to go quite some way with tunnel excavated material, that really can affect the cost of the tunnel – and that's an important point, because one can make lots of assumptions about what you would do with the spoil. But the best thing for spoil is to have a place where you can put it locally and you don't have to transport it.

282. As soon as you have to start going distances, the tunnel costs increase versus a scheme which doesn't require so much excavated material to be taken away and disposed of, because quite often the material that comes out of a tunnelling machine is not quite so useful for using in embankment fill and the like.

283. MR WIGGIN: In our pack, pages R393-R394, it gives the cost assessment breakdown for the two tunnels to the one tunnel. That is the one.

284. MR SMART: Yes.

285. MR WIGGIN: You have got a 40% contingency there. Now, forgive me, but isn't it more likely that you'd need a contingency for construction above the surface

rather than below? Because you kind of know what you're doing when you do tunnelling, don't you? It may break, but £40 million seems quite a lot.

286. MR SMART: There's a tunnel that's just stopped in Canada at the moment.

287. MR WIGGIN: You're the chief engineer. That's not going to happen to you.

288. MR SMART: It's not going to happen. But can I just say you would have a contingency on both schemes; clearly you would. For example, on the viaduct over the West Coast Main Line, there's a contingency for if you would have to get possessions or whatever you need to do with that. On tunnelling, there is a contingency for machine failures or, in fact, in the extreme, if you have to do something pretty radical with the machine because it can't cope with the ground conditions.

289. Now, what we've got here, though, is a difference in contingency. So, we're not saying here on the costing – and I'm not a cost engineer, so I'll try to explain this as best I can – that we're applying a 40% contingency.

290. MR WIGGIN: It's 40% more contingency.

291. MR SMART: Yes, it's the difference. It's the net, if you like.

292. MR WIGGIN: It's 40% on the difference between the two sort of extra 50s is what you're saying.

293. MR MOULD QC (DfT): It's essentially making sure that the cost is not underestimated. In other words, you are assuming –

294. MR WIGGIN: We were doing all right until you got involved. But, no, it is the extra; it is the differential.

295. MR MOULD QC (DfT): Yes, yes. That is the point, yes.

296. MR WIGGIN: Sorry.

297. MR SMART: This can be difficult to understand, with the way we net off.

298. MR WIGGIN: Yes, okay.

299. THE CHAIR: On the broader point of £126 million, what is the case against tunnelling? Why is HS2 Ltd recommending to us that we don't tunnel that full distance? How did you weigh the very real objections to going over with the cost implications on the taxpayer of not wanting to spend that £126 million?

300. MR SMART: Well, first of all, the £126 million is the capital cost of the difference of the scheme, but, because we've got contingency and you've got to look at that, we're saying the figure is actually £176 million.

301. There are other lifecycle effects of tunnelling, whole lifecycle costs that is, that of course do add to the cost.

302. THE CHAIR: Have you got an NPV figure for that?

303. MR SMART: This doesn't cover the fact that you've got all the electrical power for fans and pumps that you would need in longer tunnels. Also, even when you have a train on the surface, a vast amount of traction power goes into pushing air out of the way. When you go into a tunnel, that increases by 10% – so you have a further increase in traction power costs on the life of the railway of 10% more when it is in a tunnel.

304. But the point is that this is not in the Bill at the moment because of the effect on the public purse.

305. MR WIGGIN: There was one thing we observed when we went. We crossed the disused railway and we had it explained that he viaduct would have to pass over the disused railway so high up that any future train could use overhead wires.

306. MR SMART: Yes.

307. MR WIGGIN: And I'm not sure that had been fully factored in, because that puts it really very high up in the air.

308. MR SMART: It does, but I think the quote was 21 metres. Actually, it's about 18 metres to the soffit of the viaduct. You've got the construction of the viaduct and then the rail level. But it's that order, and that does allow for what's known as Network Rail electrification clearance of if ever they want to build a railway to Market Drayton that would have an electrified element in it.

309. MR WIGGIN: One of the joys of today is we've learned all about sound. When you stick something that high up in the air, it makes it a lot worse because you can't put the barriers up.

310. MR SMART: Well, you can have barriers.

311. MR WIGGIN: But they are sort of flimsy.

312. THE CHAIR: I think the Committee came back wanting a more detailed review of what would happen if the Government went to Network Rail and effectively asked to remove the unused or disused – I'm struggling on terminology because it's slightly complex – line from any likelihood of ever being used again. What would the positive environmental impact of that be in terms of lowering the profile? Would there be any cost? On one side we're looking at tunnelling or not tunnelling, and we wondered whether there was a kind of Blairite third way.

313. MR WIGGIN: A really good third way is what you mean.

314. MR SMART: Certainly, sir, you are right: if we did not have to clear what is effectively the colliery Market Drayton line at height, there would be a cost saving on the viaduct, because we'd come down. We've still got to go over the West Coast Main Line at height, because that is the West Coast Main Line, clearly – but we could come down sooner.

315. MR WIGGIN: But if you come down, that makes this £126 million an even bigger number.

316. MR SMART: Yes, it does, because we'll have a saving on the base scheme.

317. MR WIGGIN: Exactly, so I think it would be helpful to know what the final number is and whether we can get the Government to adopt that.

318. MR SMART: Okay, we can get that.

319. MR WIGGIN: Because it's very much in the Government's interest to do that.

320. MR SMART: I understand.

321. MR MOULD QC (DfT): I have asked for an up to date understanding of what the

policy and operational case for maintaining that out of use railway in its current state is, and I'll make sure that we cover that cost question that you've raised.

322. MR WIGGIN: It makes sense.

323. MR MOULD QC (DfT): You'll also of course have in mind that amongst the petitioners you're going to hear is a case pushing in quite the opposite direction, which is that not only should that railway be kept but it should actually be brought back into use, because there's a legacy to be had here through combining a relocation of the depot with bringing that railway into use.

324. Now, we don't support that, but you'll have an opportunity to consider this in the round, if you see what I mean.

325. MR WIGGIN: But it's is very much, therefore, in your interest to have done the maths.

326. MR MOULD QC (DfT): Indeed so.

327. MRS MURRAY: Just very quickly, I understand it's in the Newcastle local plan to reinstate that railway.

328. MR MOULD QC (DfT): I haven't heard that, but you may be right, yes.

329. MR SMART: We had a representative from Staffordshire County Council on the visit, and that was the view. He believed it was in the Newcastle under Lyme local plan to do something with that railway.

330. But when you do look to the west of where we were, there is not really any railway at all.

331. MRS MURRAY: No, absolutely.

332. MR WHITFIELD: If I am also right, it's not within the gift of this Bill to re-lay that line, is it? That would rest somewhere else.

333. MR SMART: It's Network Rail.

334. MR MOULD QC (DfT): That's right. It's certainly within your remit to consider

whether what we call passive provisions should be made to accommodate future improvements or changes to the existing transport network, but if that kind of question is raised before you I shall want to cover very carefully how far it really ought to be. Because, obviously, the law of unintended consequences begins to kick in very quickly.

335. MR MARTIN: Yes. In my understanding, the Newcastle under Lyme to Market Drayton railway was passed by a Railway Act in the in the 19th century which has never been repealed, and in order to close it we would actually have to have a repeal of that Act.

336. MR WIGGIN: We like repealing things.

337. MR MOULD QC (DfT): You may be right, but I certainly wouldn't be encouraging you to incorporate that amendment into this.

338. MR MARTIN: No, no, I know.

339. MR MOULD QC (DfT): No.

340. MR MARTIN: But what I'm saying is that it would actually be quite difficult.

341. MR MOULD QC (DfT): Yes.

342. THE CHAIR: We do not think the Department has given us adequate evidence that they've looked at all the options, and we would like demonstration that the Department have looked at the reclassifying of that line during this process in order to reduce the costs.

343. And, as a Committee, we'd like to look at the three options, not just two options – one being largely yours plus minor amendments, and the other being the tunnel in entirety. But we would like a clear understanding (a) that the Department has considered the option and (b) that we are happy with that overall decision.

344. So, if it is helpful, Mr Mould, can I push back to you quite heavily that at the moment we have nowhere near that degree of comfort? We need a lot more information.

345. MR MOULD QC (DfT): Your point is very well understood. Indeed, as I

understand it, your interest is not only in cost, although that's very important. But you're also interested in whether there may be some environmental advantage in lowering the height.

346. MRS MURRAY: Yes.

347. THE CHAIR: There is a huge advantage in lowering it, yes.

348. MR MOULD QC (DfT): I will take that away.

349. MR WIGGIN: If they don't care, we won't care as much – so it is very much in their interest.

350. MR MOULD QC (DfT): I understand exactly the way you put it. Can I just answer a question that you put to Mr Smart? Can I put up page R13 of this report? I think you asked a question about what was the reason for going with the Bill scheme. You see that as a matter of record at 4.28. Option D9113 is the reference number for the single tunnel scheme.

351. This is telling you why the Bill was introduced into Parliament with two short tunnels as opposed to a single tunnel. And what it's telling you is that this option, as we know, represented a significant cost increase against what is now the Bill scheme. It is more expensive to construct with a higher cost of maintenance during operation. Based on the level of knowledge and detail of the scheme at that time, the environmental benefits were not judged to be sufficient to justify the additional costs associated with the scheme.

352. So, it was a classic example of a judgement of the extent and quality of the environmental and other benefits that would come from a single tunnel scheme and the costs of realising those benefits – and the judgement was that those costs were disproportionate to the benefits. Whether that is correct is the question.

353. THE CHAIR: R394 is clear in terms of the capital, but what Mr Smart was starting to talk about were the extra, ongoing costs. And I've not seen in the papers an indication of whether that's an extra £20 million a year or an extra £100,000 a year. It would be useful to be pointed in the right direction to look.

354. MR MOULD QC (DfT): I will make sure we cover that aspect of it as well for you, yes.

355. THE CHAIR: Yes.

356. MR MARTIN: Can I just add, Chair, that clearly there are some savings as well additional expenses? There's a greater expense of operating through a tunnel. However, you've also got the greater expense involved in the steep climb to get over the viaduct, so that needs to be netted off against it.

357. MR SMART: Yes.

358. MR WHITFIELD: And the other comment we had on a trip was about whether or not a full survey had been done with regard to the long tunnel. But there were statements made that, actually, there was sufficient information already known to make these financial assessments.

359. MR MOULD QC (DfT): Do you mean a surface survey?

360. MR WHITFIELD: Last week there was a request, because there had not been a full geological survey or tunnel survey done. That would produce information that would lead into the cost and consequences.

361. There were also statements made that, actually, there was sufficient knowledge known now for the economic benefit assessment to have been made. It would be nice to see which it is, who is saying what, what the assurance is and whether there is or there isn't, if that makes sense.

362. MR MOULD QC (DfT): That's an important point, and I think Mr Smart might want to just respond on that.

363. MR WHITFIELD: Yes.

364. MR SMART: I think the point, Mr Whitfield, you referred to was contrasting the A38, where in fact we had more geotechnical and geological information. We always had an aspiration, potentially, to go deeper under the A38, but, because we didn't have the geotechnical information, we didn't know whether we could do what is known as a JAT box, which is a particular type of construction, which is actually digging out and

thrusting a box underneath the road.

365. Now, that is particularly sensitive to geotechnical information, so there the geotechnical information was almost a no go for the scheme. We had to go in the original Hybrid Bill with what we knew we could do – and we knew we could go over, because that's just a matter of a viaduct and piles.

366. Now, when we come to the tunnel, because we are using sophisticated tunnel machines, we know we can tunnel. What we don't know is the precise depth we can tunnel at, because it is an old glacial valley. We might have to go a bit deeper with the tunnel, rather than shallower. When you look at the difference that makes, it doesn't make the difference between one scheme or the other; it makes an order of £10-15 million cost difference in potentially having deeper shafts. The core of the tunnel's to a massive difference.

367. So, it would make a difference on cost – and it's a fairly small cost in the scheme of things – but it doesn't have the same effect as the parallel that was being drawn with the A38, where there was a difference insofar as whether we could even go low in the first place.

368. MR WHITFIELD: So, your assertion is that you have sufficient evidence to propose these financial figures, notwithstanding what was also said last week, that there were some people who were of the view that you didn't have enough information.

369. MR SMART: Correct. I would say we have.

370. THE CHAIR: With the Committee's permission, I was going to say thank you to Mr Smart for your presentation and adjourn for five minutes, coming back at 10 to.

Sitting suspended—

On resuming:

371. THE CHAIR: Okay, let's rock and roll through the traffic. I was expecting someone different, Mr Mould.

372. MR MOULD QC (DfT): No, Mr Smart is a man of many skills.

373. THE CHAIR: Are you getting paid double?

374. MR SMART: So, we're now moving on to the track and transport section. Hopefully we'll be a bit swifter going through this, I think.

375. So, if we go to the next slide, I'll just give you an overview of the presentation, an overview of the environmental statement and the approach we take in the transport assessment. The transport assessment is assessed as a reasonable worst case scenario, and I'll come onto that.

376. We'll cover the main transport issues which are articulated in the environmental statement. And, importantly, we'll go through the standard exhibits – so you will see these time and time again for different sections of the route but presented in the same way to convey the information that is important for you. Then we'll go through how we mitigate the impacts and significant effects both by physical means and operational means, and then the future controls on the scheme.

377. So, the next slide. So, the transport assessment forms part of the environmental statement. It identifies traffic and transport impacts, both in terms of construction and operational impacts. Operational ones are less so in the case of Phase 2A because they tend to happen around stations. There are some impacts at Crewe, but they're very minor.

378. The environmental statement reports any significant residual traffic effects, and that's really what would be in operational case – and there really aren't any in that case. And the traffic data also informs assessments of air quality, noise and community health and equality. So, it's an important component of that.

379. So, we move to methodology. Consistent with Phase One, we have discussed our methodology with the highway and transport authorities. The HS2 impacts are assessed against a future baseline. In other words, we can't take today's traffic, because we know it will be more when we do the construction.

380. So, the demand is, if you like, future proofed by looking at the local plans for forecasting what the transport will be – in this case for Cheshire County Council and Staffordshire County Council – and also using the Department for Transport's model,

which is the standard methodology for predicting how transport on the roads will increase as we look at things such as the economy and the like.

381. So, we future proof the base flow of traffic to 2023, which is the midpoint in our construction. So, we uplift the amount because we know there'll be more and then we overlay what will happen with the Phase 2A construction and operation. And of course that does take the combined effects of Phase One into account. The peak level of construction impact is assessed against this common future baseline.

382. Now, why I say it's a credible worst case is this. When we do the traffic assessments, we take the peak construction figures. And of course although they're the peak, they will only be the peak for a fairly limited amount of time, but we do assess on the peak, because that's obviously the worst case – but for most of the time it won't be at that level.

383. Furthermore, when the contractors come on board they will want to do resource smoothing, because they will not want to have, for example, their HGVs standing in traffic; it's not good for them. So, the operational impacts are assessed against an opening year of 2027 and a design year of 2041.

384. So, moving on to the scope, we look at the public transport delay and station disruption, which is not such a significant issue in this particular Hybrid Bill. We look at increased traffic flows and traffic delays. We also look at vulnerable users' severance, delay and amenity, because if we do have traffic queues it may be more difficult for people to cross and things such as that.

385. We look at the AM and PM peak and we assess those across the route, and we do that in consultation with the relevant highway authorities. And we do local junction modelling to develop how we might change the access arrangements, so we have lots of little traffic models of some of the key junctions on the line as we go down the route.

386. The reason why I say we do a reasonable worst case is that it is based on the peak construction activity. So, what happens along a route is you will have a number of construction compounds, which all need traffic coming in and out of them with materials and supplies. They kind of light up through time, because some work on a viaduct or small bridge might be there for two or three years and then it would go. But

we look at the worst case of all of these things happening.

387. We also look at our construction traffic. We assume that 50% of the workforce arrive between 8.00 and 9.00 and depart between 17.00 and 18.00 – and they will not; they will be more spread out. There are some other mitigation things that I'll come to later. And the construction traffic on the road is assessed for road capacity purposes over an eight hour day for five days a week, whereas the compounds are actually able to operate for longer than that. So, as I say, it's a reasonable worst case.

388. So, the main traffic and transport issues. Operational traffic is generally low and focused on the maintenance bays, so the future effects once we've built the scheme are centred around Stone. They are really around the shift patterns for the workers who will be in the maintenance bays.

389. Construction traffic impacts will be as a result of diversions of existing traffic due to temporary and permanent road closures. Obviously, there are the effects of the construction traffic, both HGVs to take away excavated material and to bring in vital construction components. Then there's the workforce traffic and there's the diversion of public rights of way.

390. If I may say, Chair, you asked about construction hours. The road closures are one example where we might work outside the core hours, because, rather than close a road, where the railway crosses a road we would build an offline diversion to divert the road and keep the existing road open as long as we can. Then when the offline diversion is complete and we've had our bit of railway underneath it, we then move the traffic onto the offline diversion.

391. Now, that is known as a tie in, because we're tying in our slightly changed alignment to the existing alignment either side of the railway. And, of course, you don't want to do that in peak hours when it's being used for traffic – so you might do that in quiet time such as over a weekend or even potentially at night, because it's not a particularly intrusive activity. And that is the sort of vital construction activity that you might want to do outside of core hours, because you want to do it when the traffic is low.

392. If we then go on to our traffic and transport standard exhibits, these are the things

that you will see as we march down the route and we go to various different areas. You'll see examples of these, but there is access to the strategic road network map; there are construction traffic routes and vehicle numbers map; and then there is the daily weekday traffic flows construction phase map, which sounds like a bit of a mouthful – it's colloquially referred to as the alphabet map, which will become clear when I go to that particular exhibit. And then, there's the construction traffic histograms.

393. So, over the page, you will see this is a typical map which we use to show the regional access to our railway. It shows the main roads networks. I don't know if you can quite read the legend on this exhibit. But it does show those routes we anticipate that we would be using for construction routes. But I should add at this stage that of course all our construction routes are subject to the approval of the local highway authorities. Anything over 24 lorries a day on a route requires their approval. These are very much at the moment our view of what we would do but we are, as I've said, already talking to the local highway authorities, but these of course will have to be subject to their approval.

394. I'm going to go to the next slide, which is zooming in a bit more on a particular area, and then what you can see here is how we would depict actual traffic movements on the road. I'm having trouble to move the legend – but if you just take the top box, where it says '1250' – that is the HGV movements. And that is two way flow. In other words, that's 625 in one direction and 625 in the other direction, which gives you the 1250. That shows you the peak flows which is basically when flows are 70% or more of the peak. And there's also busy periods, when it's 50% more than the peak. And the two boxes underneath show you the months where it is busy – and I can't read the legend on the – months' peak – and then months' duration I think that is.

395. MR MOULD QC (DfT): It's months busy and months peak, yes.

396. MR SMART: Yes, that's right. It gives you the busy months, the peak months and then the level of traffic that would occur.

397. MR WHITFIELD: Does that mean there are seven months that it's busy? Or is it talking about July.

398. MR SMART: Seven months.

399. MR WHITFIELD: Seven months. So, the five – is of those seven months, five months are the peak?

400. MR SMART: – are peak. Yes, which is at the 70% or more. And that will become clearer when I show you the histograms. So, if we move to the next slide, which is probably zooming in a bit more? You can see why we call these the alphabet maps. These show particular points on the road and then they give you some statistics – which I'll come to in a minute – because I'll explain it on the next slide. But you can see how it gives you the distribution of traffic along the various anticipated construction routes. So, if we go to the next slide, it will explain what those boxes show?

401. What we have here is this shows that in 2023, on point E on the alphabet map, there will be 5,805 vehicles on that route – total vehicles – of which 403 today are HGVs. And that percentage of HGVs in relation to all the vehicles is 7%. So, in other words 7% of vehicles on that road are HGVs.

402. MR MOULD QC (DfT): That's without HS2.

403. MR SMART: That's without HS2. That's the future baseline for 2023. Then we have the HS2 traffic. What this shows is that we will be putting 693 all vehicles on the road at point E, of which 625 are HGVs. And so, when you look at the future baseline plus the traffic generated by the HS2 construction, it means that there's a percentage increase in the total number of vehicles on the road of 12% and an increase in the ratio of HGVs of 16% – in other words, about 9% increase, if you like.

404. MR MARTIN: I don't think it does. I think what it shows is the percentage of the future baseline plus HS2 vehicles which are HGVs.

405. MR SMART: Yes, sorry, that's right. Sorry.

406. MR MARTIN: The percentage increase of HGV traffic it would be 140% increase, wouldn't it?

407. MR SMART: That 16% relates to the total.

408. MR MARTIN: Yes.

409. MR SMART: What it's saying is that, while on the baseline 7% of the total traffic

is HGVs, when you put HS2 on 2023, the ratio of HGVs goes to 16%. So, there's a higher proportion of HGVs in relation to the general traffic.

410. MR MARTIN: Right. Yes. Significantly more than twice as many.

411. MR SMART: Well, it's –

412. MR MARTIN: Yes.

413. MR SMART: Our increase is 625 compared to a 403 existing.

414. MR MARTIN: Yes.

415. MR SMART: Yes. And that's based on a 12-hour flow over the peak months.

416. MR MARTIN: Yes. I'm just intrigued with why you – although you've got a percentage increase for all vehicles, you haven't got a percentage increase for HGVs. I would have thought if you're doing percentage increases, you'd have a percentage increase for HGVs.

417. MR SMART: What it's trying to show is that if you look at the road in terms of all the vehicles that use it – it's giving a proportion of what that means in terms of the relationship to HGVs compared to all vehicles.

418. THE CHAIR: HS2 limited on presenting their case. They are not presenting the totality of the universe.

419. MR MARTIN: Yes.

420. THE CHAIR: They're presenting their case well.

421. MR MOULD QC (DfT): I'm just going to add to that – although I'll probably dig a hole, but I'll try not to – we used to find – if you presented the ratio that you identified, we used to find with Phase One that with roads which had very few HGVs on them at the moment, where we had quite a substantial number coming in for a relatively short period, it would show up as an enormous percentage increase – 2,500% – which caused enormous concern to people. And we felt that on balance it was better not to frighten the horses in that way, but to try and present the ratio in what seemed more – realistic, if you like. But as you say, if people feel that it's more realistic to present that

other ratio, then they will no doubt do so when they bring their case to you.

422. MRS MURRAY: You are showing the actual predicted figures so it leads anyone who wants to look at that to be able to determine it themselves.

423. MR SMART: It's the mix of traffic that people experience out on the roads, is how it is regarded.

424. MR MOULD QC (DfT): Experience tells us that this – as you rightly say, if I may say Ms Murray – the presentation of traffic data in a form that is both comprehensible but also one hopes as uncontroversial as it can be is terribly difficult. And this our attempt now to try and do that in that way. I am actually quite confident that we will find from time to time that the petitioners will say, 'No, no, you still could do this more effectively and more fairly'. And we will obviously see whether there are lessons we can learn in that respect. But this is where we are at the moment on this. Yes.

425. MR SMART: And I should also say that what will also come out on individual petitions is that sometimes these figures – if we close a road for a period of time and have diverted traffic, this would also include those figures. So, it could be higher for a period of time because we've got diverted traffic using a route and then when we re-open it, it goes away. So, that would also come out on these slides. So, if we go to the next one?

426. I think this is perhaps a bit clearer, explaining how we do this. On an individual road, we would look at what we call a histogram, which shows are anticipated movements based on a month by month basis. You can see that whilst our assessment for, if you like, the suitability of the road, would be done on the very highest figure there – which is the 1,200 – which is why I say the reasonable worst case for assessments – nevertheless, we'd be saying peak period would only occur over those months – those central months. And then, the busy period would be at the 600. We'd use the 600 figure for the busy period and just over 800 for the peak, just to put that into a relationship on a particular road – but we look on it on a month by month basis.

427. MR WHITFIELD: Go back to the construction traffic, the page 10 one, where we have the rectangular box, where we have the six busy months and the five peak months.

The five peak months are the five points above the red line on the histogram.

428. MR SMART: Yes.

429. MR WHITFIELD: And the six months are the ones that fall between the blue and the red.

430. MR SMART: Correct.

431. MR WHITFIELD: And that's what gives –

432. MR SMART: That's what –

433. MR WHITFIELD. Right.

434. MR SMART: Yes. So, if we go to the next slide. Basically, the histogram shows the construction forecast two way flows for HGVs and traffic flows presented as a daily average for each month and based on those two peaks and busy periods, which you've just highlighted, Mr Whitfield. That's how the construction histogram works. And they would be done on a particular road if there were issues with that in a petition.

435. Moving on to mitigation of traffic impacts. These can be done by physical means in construction. For that, we would keep roads open where reasonably practical, including the provision of off-line diversions, which I've just explained how we do that. One thing that prevents an off-line diversion is if you would have a lot of local housing and so you have nowhere to create the off-line diversion without demolishing houses. That can be a problem where we might have to close the road for a period where we build the new road and not do an off-line diversion. But generally speaking, we try and do an off-line diversion.

436. The use of the railway trace – this is like an area to the side of what is the 22 metre width of the railway – where we can run construction traffic. There are some limitations to that because certainly big yellow Volvo or Moxy type moving earthwork machinery can easily operate on those roads; HGVs less so. There's also a cost implication because if you've got HGVs coming on there, you can't use pink diesel. So, there's an increase in cost. But we do try and use the haul roads where we can. There are often blockers to a haul road. So, you might have a point where you can get along a haul road

but then there's a construction of a viaduct or bridge, which means you can't get across without having quite an expensive, potentially difficult temporary arrangement. But we try and use that where we can.

437. And we also look at specific highway improvements to address potential delays and road safety issues such as sight lines – also clearly an issue for us if we're near schools and things like that. And we obviously liaise with the local authorities on that. And we are doing work with them to see what improvements we might do ahead of our construction so they're already in place before any of our construction traffic hits the highways. There are temporary measures. And I think the best example of that is the M6 slips where at Stone in order to get straight on to the best route we can, we're putting in some temporary slip roads which the highways authority will accept as temporary. But to make them permanent we haven't got the sufficient sight lines and space to make them available for a permanent, public car use. But we would be able to use it for our construction traffic –

438. MRS MURRAY: Have they actually asked if you would be prepared to leave them so that in future they could be developed into an additional slip road?

439. MR SMART: We can certainly look at that – but there are some spatial constraints on us that we wouldn't be able to meet the highway's – what's known as the design and bridge manual standards. Now, we could potentially look at that. But at the moment we have in our discussions with the highways authority, we haven't found a way in which we would be able to do that.

440. MRS MURRAY: Okay.

441. MR MOULD QC (DfT): When that point is raised – which I think it will be – I shall need to make sure that we let you know what Highways England – as the responsible highway authority for the motorway – what their attitude to that proposition is because it does raise some difficulties in relation to spatial standards between junctions and so forth that they may well have concerns about.

442. MR SMART: Yes, in relation to speed and things like that. And also, of course, as the Committee is aware, we have used on Phase 2A borrow pits, which is basically gravel pits, if you will – or it could be sand pits – where we excavate material which we

can use in construction to save importing it on the roads. We might have to use the roads locally. If we can, we'll move it along the trace, as we call it – the haul road. But also, there's an opportunity because we're restoring the borrow pits to also use it locally to put in excavated material that is not of suitable quality to build the railway but is still suitable for land restoration. And therefore, not have to take it on to the M6 and take it a long distance. As I was talking about earlier with the costs of tunnel, of excavating material.

443. If we then go on to operational controls, other than the physical things we can do there. Our main construction routes are obviously submitted to the planning and highway authorities so we can't – anything more than 24 – that's two way movements – a day has to go for their approval. Use of routes with direct access to the strategic road network is what we try to do, but it can be limited. You saw the issues we have for the roads in the area but we are trying to use the best possible road that we can. We'd like it to be A roads but it can't always be, if the line of the railway is some way away from the road network.

444. The code of construction practice, which I believe is in your bundle and you're probably very familiar with, has transport measures built into it, via the contractual arrangements that the contractor has to comply with to ensure that is properly managed and includes a traffic management plan, which of course is discussed in local liaison meetings with the local authorities. And HS2 has continued to work with the local authorities to ensure that substantial traffic and transport affects are addressed. We do have traffic forums that involve all the country or transport authorities and we also have specific ones with them as well as the general ones, which cover more general things for our approach.

445. MR WHITFIELD: Can I just ask? The code of construction practice – this transport – this is the hot line, where people are phoning up –

446. MR SMART: Yes.

447. MR WHITFIELD: – saying, 'There's an extra truck going down my road'. And this is where the more reactive instant find out about it happens?

448. MR SMART: Yes. And I think if I could just make a point on that. Quite often

people have – you get somebody in China or something, who doesn't know anything about what is happening. So, the point of having one hot line is because that would go to a central always manned HS1 exchange, if you like. But that exchange has who are the duty managers on particular sites, who can get to the sites. You're not going to go to somebody who says, 'Well, I don't know'. But you've got to have one number and you can then manage the distribution of that.

449. MR WHITFIELD: And is that what the hot line is mainly used for, transport issues?

450. MR SMART: Noise is another one.

451. MR WHITFIELD: Noise.

452. MR SMART: Certainly, my experience it was usually noise. Once had a farmer who shot a pump because it was too noisy, which was an interesting way of doing it. But, yes, it could be traffic issues. But as I said, or if I didn't, I did mean to, that of course it is not in our interest to have our construction vehicles sat in traffic.

453. MR WHITFIELD: No.

454. MR SMART: We would want to manage this so that there is an advantage not just of course to the local residents and the road users, but to us, because we don't want to have delays that we can't get excavated material away other than at the significant cost of sitting in traffic queues. If I go to the next slide?

455. Construction traffic routes – as I've said – anything larger than – well, more than 24, but also over seven. Five tonnes will require local approval under the schedule 17, except motorways and trunk roads – and access to compounds. I've mentioned the 24 point. Planning authorities may refuse some of our proposed construction routes unless we do particular measures to improve things like junctions and address their road safety concerns. Or there could be grounds such as archaeological, historical, nature conservation concerns. That's why it's in our interest to work with the local authorities as early as possible so we can embed these plans and be sure of how we can manage the construction. So, that is something you can do better further into the construction phrase, when the contractors have got more understanding of how they can resource

smooth activities, when they get scripts with more detailed construction plans.

456. MRS MURRAY: Have you or do you carry out an assessment on the types of heavy goods vehicles that you would be using – i.e., so many 7.5 tonners; so many 16 tonners; so many low loaders?

457. MR SMART: We generally use –

458. MRS MURRAY: Roughly?

459. MR SMART: Well, where we that bites – if I can use that term – is where you get into exceptionally long low loaders. And then you've got what are known as exceptional loads. So, even if you've got a general understanding of the local authority to use a standard six or eight wheel excavated material – commonly known as a 'muck wagon' – which have to be sheeted and wheel washed and all of those things – but once you get into exceptional loads of long loads, you would need to get special approval from the local authority to move them anyway at certain times. Which again could be something that might breach the core hours, because if you have a very, very long – one thing we talked about earlier was a tunnel cutter head – that's a big piece of iron and steel to move. And that might come in on an exceptional load. It's more when you have very long –

460. MRS MURRAY: Would that be a wide load, as well? And I know some counties require escorts?

461. MR SMART: Yes. That would be agreed within the traffic and management plans that we would deal with the local authority if there were instances that we would have a number of types of wagons that would fall out with that standard, generic profile.

462. MRS MURRAY: Thank you.

463. MR SMART: Moving on to the next slide, which is traffic management and site specific measures. There are a number of things that we do. And those are set out in the draft code. They address phasing of the works; the timing of operations – I've mentioned road management – and parking controls.

464. We could have things that might limit are movements around hours when for

example schools were in operation and parents are picking up children from school; monitoring of vehicles arriving and leaving construction compounds; monitoring of deviation from authorised routes.

465. Sometimes it's difficult – clearly anything like HGVs that are subcontracted and are very, very visible – it's easier. If you have ordered some potential equipment that is coming from some part in the UK, of course it is much more difficult to say, 'You've got to use a construction route'. And in fact, you wouldn't want to limit that because obviously that might come from people in a not reasonably immediate vicinity who would be supplying the sites and therefore getting some benefit from it.

466. Measures for highway reinstatement are agreed, emergency access protocols are agreed. We would want to make sure we can always get emergency vehicles in. If we were to stop a road, for example, we would need to make sure how emergency vehicles could access down the road if they needed to do that. And arrangements for liaison, as I've said, with relevant highway authorities.

467. All of this now tried and trust methodology is built into the draft code of construction practice and as probably you've heard from Mr Mould, is a one way ratchet. The reason it is a draft – it can't get worse but it could get better if we agree certain things. And so, for the next slide?

468. We have workforce travel plans so obviously we will encourage our contractors as part of the mitigation that where they can, rather than have workers coming in by car and all coming in in their own cars with one person – that we manage that by using a workforce plan which could include busing the workforce in and set targets for how we can reduce that. That's another thing that is built into our contracts with the contractors. I think that is the last slide, I believe. So, I think that has been a fair canter through but hopefully it has given you a bit of an overview of what you can expect to hear a lot about in some of the petitions.

469. MR WHITFIELD: Can I just ask, how we know what the traffic flow on the A518 Western Road in September '22 is but we're not sure about how many boring machines it needs for a tunnel?

470. MR SMART: We are sure about the boring machines because I've said two. But

when a contractor gets on to site and we get better ground conditions and we understand the complexities of what else has been happening – as our design develops, it could be that we would push ourselves into four. But that's a much lumpier item, if I can use that term. The reason we are sure – we're not sure – but it's the reasonable worst case – is because what we've had a look at is what we think the programme will be, allowing for reasonable construction times with different construction techniques on the route – whether it's a viaduct, a bridge, a cutting or embankment – we've looked at what we think would be a reasonable construction programme to achieve our overall programme. And then you look at what you need to do. So, for example, an average muck wagon takes 8. 5 cubic metres of material. So, it's quite easy to do a long division to say, 'Well, if you're going to move that in six months, you're going to need this number of wagons and that's the sort of place they'll go'.

471. MR WHITFIELD: So, are these plans dynamic enough? Of course, it won't happen if there is a substantial change and it knocks on and slows down. What's the real day to day affect from the point of view of the transport people and everything?

472. MR SMART: If of course the contractor resource smooth, what tends to happen is that the peaks are a lot less but there might be for slightly longer periods of time – but there's less impact into the road because you haven't got as much traffic on it. But there's a balance to be struck, and that occurs when we get more design done and a better understanding of the contractors' programme. It could depend on the technique. The contractor decides to build, for example, a viaduct – whether you're going to need to import more pre-cast concrete or whether you want to build in situation on site. They both require to have traffic to support that logistically. But there will be a difference in terms of what they might generate.

473. MR WHITFIELD: Thank you.

474. MR MOULD QC (DfT): There's a legal perspective to this, which it may be worth just mentioning. These numbers provide an envelope, in effect, within which we say we can be confident that we can build this railway. And that envelope is necessarily quite conservative at this stage so that we can say to people, 'It won't be any worse than this'. But it follows from that, as Tim Smart says, that it may actually be possible for the contractor to make it better. We can't guarantee that, so in order to enable you to

assess the petitioners before you on a robust and conservative approach so that you can at least have the confidence of saying, ‘Well, it can’t get any worse than that’ we present you with figures that are on that precautionary and conservative basis.

475. MR WHITFIELD: That is to say, with the finance, you are confident that those figures as the reasonable best scenario are defendable.

476. MR MOULD QC (DfT): Yes, I think that is right and the department I think prepare their costings and their economics on that basis, yes. Yes.

477. THE CHAIR: Thank you very much, Mr Smart, Mr Mould. We’re looking forward tomorrow, not only because we’re not sitting in the morning, but we’re starting our next phase, moving to the right to petition, which is a new experience. Thank you very much for the time to date.