Neutral Citation Number: [2026] EWHC 941 (KB)

Case No: QB-2021-002484

IN THE HIGH COURT OF JUSTICE
KING'S BENCH DIVISION

Royal Courts of Justice
Strand, London, WC2A 2LL

Date: 24/04/2026

Before:

MR JUSTICE GARNHAM

- -

Between:

DAVID ABBOTT AND OTHERS **Claimants**

- and -

MINISTRY OF DEFENCE **Defendant**

- -
- -

Harry Steinberg KC, Aliyah Akram and James Pickering (instructed by **Hugh James**) for the **Claimants**
David Platt KC, Peter Houghton and Kate Longson (instructed by **Keoghs**) for the **Defendant**

Hearing dates: 6, 8, 9, 10, 13, 15, 16, 17, 21, 22, 23, 29, 31 October 2025
11, 12, 13, 14, 17, 18, 19, 20, 21, 26 November 2025
1, 2, 3, 4, 8 December 2025

- -

Approved Judgment

This judgment was handed down remotely at 10.30am on 24 April 2026 by circulation to the parties or their representatives by e-mail and by release to the National Archives.

....

MR JUSTICE GARNHAM

Mr Justice Garnham:

Introduction

1. For centuries, it has been recognised that human hearing can be damaged by exposure to loud noise. In *Corpus Hippocraticum*, in the fourth century BC, Hippocrates described patients with ringing or buzzing in their ears. Sometime between 600 and 200 BC, two Indian physicians, Charaka Samhita and Sushruta Samhita, described a pathological condition called "*Karna Nada*", an expression which means ringing in the ears. In *Naturalis Historia,* Pliny the Elder (23-79 AD) coined the term "*tinnitus*" to describe the ringing in the ears experienced by fishermen of the upper Nile exposed to the noise of waterfalls.

2. As is well known, the 20th century saw progressively more thorough recognition and regulation of noise at work. In 1908, the Annual Report: Factories and Workshops said "*It is generally known that men employed in certain trades are liable to have their sense of hearing seriously impaired, if not entirely destroyed in the course of time, as a result of long continued exposure to loud noises. One well known instance is that of boilermakers' deafness.*" In 1963 the Ministry of Labour published "*Noise and the Worker*". In 1972 the "*Code of Practice for Reducing the Exposure of Employed Persons to Noise*" was produced.

3. In 1983, Mustill J gave judgment in the seminal case of Thompson v Smiths Shiprepairers [1984] QB 405, in which he concluded that "*the year 1963 marked the dividing line between a reasonable (if not consciously adopted) policy of following the same line of inaction as other employers in the trade, and a failure to be sufficiently alert and active to measure up to the standards laid down in the reported cases.*" The Noise at Work Regulations 1989 came into force 5 years later. Those Regulations were replaced in 2005 by the Control of Noise at Work Regulations.

4. This judgment follows the hearing before me of two test cases and a number of generic issues arising from a series of claims for damages for noise induced hearing loss ("NIHL") brought by former members of His Majesty's armed forces. The solicitors for all the complainants are Hugh James and accordingly the litigation has been known as the "Hugh James Military Deafness Litigation". I understand that there are many thousands of other military NIHL cases awaiting this judgment.

5. I am very grateful to the legal teams of both parties' for the prodigious amount of work that went into preparing and presenting their respective cases.

6. The judgment is divided into three parts and 19 chapters:

PART 1 – The Background

PART 2 – The Generic Issues

PART 3 – The Two Remaining Test Cases

PART 1 – BACKGROUND

Chapter 1 – The History

7. This litigation was begun by the issue of a claim form on 9 August 2017 in the name of Adrian Turner and 209 others. The solicitors' firm acting for the Claimants was Hugh James. On 28 June 2021 Hugh James issued a further claim form in the name of David Abbott and 3,449 others. By each of those claims the Claimants sought damages for NIHL against the Ministry of Defence.

8. Since then, the number of Claimants has expanded considerably, and other solicitors' firms have commenced similar litigation. The total number of claims now stands at 10,440. Of these, 8,138 are claims where Hugh James is instructed for the Claimant and 2,302 are claims brought by other firms of solicitors.

9. In the spring of 2024, the Hugh James Claimants and the Defendant reached an agreement disposing of issues of Crown immunity, combat immunity, breach of duty, contributory negligence, apportionment, Noise Imission Levels and limitation. The vehicle devised for the implementation of this agreement was termed the "Matrix". That Matrix was annexed to an order of the Court made in July 2024, the effect of which was to leave only causation and quantum in issue in return for a structured discount on any damages.

10. By a series of orders, the assigned Master, Master Davison, and I, as the assigned judge, gave directions for the conduct of this litigation. In particular, following the conclusion of the Matrix agreement, we approved a list of six "lead cases" which it was agreed would be tried first, and a list of "generic issues" identified by the parties as likely to arise in a large number of the cases.

11. Three of the lead cases were selected by the Claimants' solicitors and three by the Defendant's solicitors, the common purpose of which was to achieve a mix of cases the resolution of which would provide the parties with guidance as to the proper approach to disposing of the remainder. "Reserve" lead cases were also identified which would be made ready for trial in the event that any of the six lead cases settled before trial. A "cut-off" date was identified in September 2025, after which it was agreed it would not be possible to ready a reserve case for inclusion in the trial then fixed for 6 October 2025.

12. The generic issues were agreed with a view to obtaining judicial determination of significant issues which arose in a significant number of the cases in the cohort. The Defendant conceded by letter that all the Claimants had "*sustained sufficient noise exposure during military service as to be capable of causing noise induced hearing loss*".

13. In the week before this hearing began, two of the test cases, namely those of Andrew Davies and Stephen Hambridge, were compromised. From the standpoint of the conduct of the entire litigation that was, perhaps, unfortunate because it meant there could be no judicial decision on two cases which the parties thought would be usefully illustrative for the whole cohort. However, plainly it was right for the parties to come to terms in cases where both sides agreed that the proposed settlements were in their respective clients' best interests. In

addition, in the last week of September 2025 two of the reserve cases, namely those of Joshua Law and Trevor Hobbs, were also settled. Each of these cases was settled after the cut-off date.

14. During the third week of the hearing two of the remaining four Claimants applied for permission to withdraw their claims. By CPR 38.2(1), ordinarily a Claimant may discontinue all or part of his claim, against one or more Defendants, at any time. However, CPR 38.2(2)(c) provides that where there is more than one Claimant, a Claimant may not discontinue unless every other Claimant consents in writing or the Court gives permission. Given the substantial number of Claimants in this litigation, it would not have been practical for written consent to be obtained from each of them and, accordingly, they each sought permission to discontinue their claim. No party should be compelled to litigate against their will and accordingly, in a separate judgment, I granted them permission to withdraw their claims.

15. The result was that we were left with just two test cases, those of Mr Christopher Lambie and Mr Jack Craggs, the former being a test case chosen by the Claimants' solicitors, the latter being chosen by the Defendant's solicitors. In Lambie, a diagnosis of NIHL had never been in dispute, only the extent of any hearing loss. In fact, the Defendant subsequently accepted the quantification exercise advanced by the Claimants, although expert evidence was called from Mr Silva and Dr Nassar and the case remained significant on the question of quantification of such claims.

16. The question then arose as to whether I could, against so narrow a background of test cases, determine the remaining generic issues. I concluded that I could, and should, for two reasons.

17. First, almost all of the disputed generic issues are live, to some extent, in the case of one or other or both of the test cases. So, in Mr Lambie's case the reliability of military audiometry, the quantification of NIHL (including the comparative database), acceleration and latency, general damages, the Ogden Tables approach to loss of earnings, and the cost and adequacy of hearing aids, are all in issue. And in Mr Craggs' case the reliability of military audiometry, acceleration and latency, cochlear synaptopathy, causation of tinnitus, arguably the *de minimis* issue, general damages and the cost, necessity and adequacy of hearing aids, all arise. The dispute as to how military NIHL should be diagnosed and quantified is fundamental to much of this.

18. For those reasons it seems to me that all the generic issues identified above can legitimately be addressed in this judgment.

19. Second, the cases of Lambie and Craggs were identified as test cases for this whole cohort. The parties, the MoD and those represented by Hugh James Solicitors, have conducted this entire litigation on the basis that these generic issues would be determined by it and that those determinations would bind each side, so far as they are relevant, in all the other cases in the cohort. Huge expense had been incurred by both parties and there has been a considerable investment of judicial resource in addressing these issues. I see no possible justification for the Court not setting out its conclusion on each issue.

20. It is right to say that this Military Deafness Litigation is not conducted under a formal Group Litigation Order ("GLO") under Part 19 CPR. But, as both counsel submit, it bears considerable similarities to such litigation. There has been common case management, a Group Register, generic issues, common costs and lead cases designed to resolve the relevant issues. The parties have the joint understanding, in common with CPR 19.23(1) on GLOs, that "*the judgment or order is binding on the parties to all other claims that are on the group register at the time the judgment is given or the order is made unless the court orders otherwise*".

21. To put it another way, as Mr Platt KC does for the Defendant, the judgment to be produced by the Court at the end of these proceedings was always intended to have *in rem* effects amongst the cohort and not simply be an *in personam* determination of narrower issues between the competing parties in particular cases.

22. Mr Platt drew my attention to the judgment of Fraser J (as he then was) in Bates v Post Office Ltd (No.2) [2018] EWHC 2698 (QB). The judgment concerned an unsuccessful application by the Defendant to strike out a large part of the lead Claimants' evidence, on the grounds that it was not relevant to the common issues. Fraser J held that there were good arguments that it should be harder to strike out evidence, not easier, in group litigation. That was because common issues, or the cases of lead Claimants, were selected at an early stage in group litigation. Relevance had to be considered against the litigation as a whole; unless that was done, steps in the litigation (such as resolving at trial common issues that would be relevant to hundreds of Claimants) might be taken on an artificially narrow basis. For the evidence to be struck out, it had to be quite plain that, no matter how the proceedings might look at trial, the evidence would never appear to be relevant or, if relevant, would never be sufficiently helpful to any of the common issues. That was "quite a heavy burden".

23. In Ocensa Group Litigation (Arroyo v Equion Energia Limited [2016] EWHC 1699 TCC), four cases out of 109 Claimants proceeded to trial. At the conclusion of the trials, Stuart-Smith J (as he then was), "outlined in detail the strengths and weaknesses of the expert evidence, in part to assist the parties in considering the merits of the cases that were not tried". At paragraph 7 he held:

> In briefest outline, I have concluded that all four of the Lead Claims that are the direct subject of this action fail. Very largely they fail on the facts; but I have in each case also considered the legal basis on which the Claims were brought and the application of relevant principles of Colombian Law to each claim. The purpose of this judgment is to decide the four Trial Lead Claims and to provide a basis for the resolution of the claims regarding the 69 farms that were not considered in detail at the trial. To that end I have, as requested, made extensive findings about Colombian Law irrespective of their direct applicability to the four Trial Lead Cases. I have also considered the entire body of expert evidence in considerable detail, outlining what appear to an English Court to be the strengths and weaknesses of the expert evidence that was led and tested at trial. That has been made necessary partly in order to reach necessary findings in the Trial Lead Cases and partly

so that the parties may appreciate their general position on the expert evidence when considering the merits of the cases that were not tried.

24. In those circumstances, as I made clear would be the case during the hearing and in my earlier ruling, this judgment addresses all the generic issues identified above.

Chapter 2 – Procedure and Witnesses

25. The procedure adopted at trial was, in substantial part, entirely conventional. The Claimants adduced evidence by the production of witness statements in the case of lay witnesses and expert reports in the case of expert witnesses, the accuracy of which each witness was asked to confirm under oath or affirmation. Each was then cross-examined and, as necessary, re-examined.

26. The exception to this conventional approach was in relation to the Auditory Physiology experts, Professor Christopher Plack and Professor Andrew King. In their case, there was a joint approach by the parties inviting the Court to hear the two experts concurrently ("hot tubbing"), in a manner similar to that adopted during the NIHL primer referred to below. Unlike the primer, however, this was formal evidence from the beginning.

27. All the evidence in the case was recorded and transcribed by a "live-note" stenographer which means a complete record of the evidence was available to the Court and the parties as the case proceeded. It also means that there is a comprehensive transcript of proceedings throughout this lengthy trial and that I do not need to summarise everything said by each witness. Instead, I refer below to the evidence relevant to each issue under discussion.

28. I heard and read lay evidence from the two Claimants, Christopher Lambie and Jack Craggs, and from Samantha Lambie (Mr Lambie's wife) and Elizabeth Condit (Mr Craggs' mother), and from Major General Philip McNee (former Surgeon General to the United Kingdom's Armed Forces).

29. The subject matter of much of the expert evidence was highly technical and the topics addressed particularly esoteric. In total 13 experts were called to give evidence and submit to cross-examination. In the case of Mr Lambie, I heard from Mr Priyamal Silva (consultant otolaryngologist), Dr Gregory Nassar (audiologists), and Mr Joseph McKerns and Mr Jonathan Hailstone (employment consultants). In the case of Mr Craggs, I heard from Mr Green and Mr Zeitoun, ENT surgeons, Professors Moore and Lutman on auditory perception, Mr Hussnain and Dr Nassar on hearing aids, and Dr Mahmood on speech in noise testing. (I received an employment expert's report in respect of Mr Craggs (from Mr Dom Hill), but since the claim for loss of future earnings for Mr Craggs is not pursued, I do not need to refer to this further).

30. I also heard from experts who gave what was called "generic evidence", evidence relevant to this class of case generally, namely Prof. Plack and Prof. King (auditory physiology experts), Prof. Moore and Prof. Lutman (audiology and auditory perception experts) and Mr Graham Cox and Mr Kevin Green (ENT specialists). I also received agreed expert evidence on acoustic engineering (from Mr Kevin Worthington and Mr Timothy Ward) and on statistics and epidemiology (from Professor John Norrie and Professor Damien McElvenny). This generic expert evidence was not focused solely on the facts of particular cases but ranged widely across the relevant subjects because of the generic nature of the questions before the Court. In the course of this generic evidence there was frequent recourse to what Mr Platt called "*often arcane and competing academic*

literature". The "*Core*" literature bundle runs to almost 1,000 dense pages of material; the full literature bundle exceeds 12,000 pages.

31. Recognising in advance the complexity of the relevant material from the reports produced, I invited the parties to provide what I called "*a judicial primer*", in the form of a joint written report from the parties' two ENT experts, Mr Cox for the Claimants and Mr Green for the Defendant. That was not intended to be evidence in the case but was designed as an introduction for a non-specialist Court to the relevant science. The two experts then spoke to that joint report and answered questions from me in open Court and in the presence of the parties' counsel before the commencement of the evidence. For the Court, that was an invaluable exercise, providing an essential grounding in some of the basic concepts and the relevant topics.

32. The parties too found the primer useful, and counsel subsequently invited me to admit the written primer report into evidence, which I did. I summarise its contents in the next chapter.

33. At the opening of the proceedings, I had the benefit of a detailed written opening from the Claimants (running to some 135 pages) and detailed generic and case specific skeleton arguments from the Defendant (running in total to 301 pages). At the end of the evidence, I received comprehensive closing written submissions from the Claimants (of 429 pages) and from the Defendant (446 pages) and heard oral submissions over five days.

34. Before departing from this chapter, I would add this about the procedure adopted here. The original time estimate for this case was 10 weeks. In fact, with four of the original test cases not proceeding, the hearing of evidence and submissions took only 28 days. However, the volume of material to be marshalled and presented by the parties and considered by the Court made it essential that a number of short breaks were built into the timetable. As a result, the hearing lasted in total just over 9 weeks.

35. In future group litigation in disease cases, particularly those with a greater number of test cases, it seems to me essential that adequate provision is made in the timetable not only for the consideration of each test case and each generic issue, but also for breaks to enable the parties to present the evidence properly and for the Court to analyse it as the matter proceeds. There will be cases where an issue-by-issue process, with submissions and rulings on each, might prove most advantageous.

Chapter 3 - The Judicial Primer and Agreed Evidence Relating to NIHL

36. At my request, made some months before the start of the hearing in this case, the parties agreed to provide me with what I called "a judicial primer" produced by the ENT experts, Mr Cox and Mr Green. This was designed as an uncontentious account of the essential science and technical background to the issues in the case.

37. It was initially intended that the primer would not be treated as evidence in the case. However, once produced, it was plain that it would be useful for the further conduct of the litigation. The parties made a joint application that it be admitted into evidence and I agreed. Since it is now in evidence in this litigation, and provides valuable background material, I begin by summarising the parts of it which proved to be relevant to the issues which arise.

38. There was much agreement between the parties in different disciplines and I address that in subsequent chapters. But of particular assistance for an understanding of the background was the agreement of certain essential principles between the audiology and auditory perception experts, Prof. Brian Moore and Prof. Mark Lutman. At the end of this chapter is a summary of their agreed evidence on those principles.

39. I have also included in this chapter some observations on sensitivity and specificity, concepts which are fundamental to evaluating diagnostic tests.

Sound and Noise

40. Sound is a form of energy produced by vibrating objects. When an object vibrates, it causes the surrounding molecules to oscillate and transmit the vibration outwards, forming a pattern of compressions and rarefactions. This results in pressure waves that travel through a medium, most commonly air. These are detected by the ear or measuring instruments. When they reach the ear, the pressure fluctuations are transmitted to the auditory system in the sensation we recognise as hearing. The characteristics of sound include its amplitude (loudness), frequency (pitch), and quality (timbre), all of which contribute to how we perceive different sounds. The alternating pressure fluctuations give rise to the sounds we perceive. The pressure fluctuations form longitudinal sound waves, because the air particles move in the same direction as the vibrations.

41. Noise is generally defined as an unwanted or disturbing sound or one which interferes with normal activities such as communication, work, or rest. The perception of noise is subjective and can vary depending on an individual's sensitivity, the context, and the environment in which the sound occurs. Noise is often measured and assessed in terms of its impact on health, safety, and well-being.

Amplitude and Pitch

42. The amplitude of a sound wave is a measure of its strength, perceived as how loud or soft a sound is. A larger amplitude corresponds to a louder sound, while a smaller amplitude corresponds to a quieter sound. The amplitude of a sound wave

represents the maximum height of the wave from its resting position, either to the peak or to the trough of the wave. Amplitude is measured in decibels (dB).

43. The pitch of a sound is defined by its frequency. Frequency is the number of compressions that pass a particular point at a given time. This is measured in cycles per second, or Hertz. 1 kHz = 1,000 Hz. Higher frequencies result in higher pitches, whilst lower frequencies result in lower pitches. Humans can typically hear sounds between 20 Hz and 20,000 Hz (20 kHz). Each musical note corresponds to a specific frequency. For example, middle C is around 262 Hz.

Sound Pressure and Sound Intensity

44. Sound pressure is a variation in air pressure caused by a sound wave. It is the local deviation from the ambient atmospheric pressure, measured in pascals (Pa). Since the range of audible sound pressures is vast (from the faintest whisper to the loudest sounds), sound pressure levels (SPL) are measured using a logarithmic scale to represent these pressures. SPL is expressed in decibels, typically as dB SPL or dB referenced to 20 µPa (the reference pressure for human hearing). The lowest sound pressure that can be heard is the hearing threshold. The pain threshold to loud sound (which may be a million times greater) may limit testing of very loud sound. Factors such as the distance from the sound source, reflections from surfaces, and the surrounding environment can affect sound pressure levels.

45. The intensity of noise or sound is known as acoustic intensity. It is defined as the power carried by sound waves per unit area, in a direction perpendicular to that area. It is also called the sound power density and the sound energy flux density. The SI unit of intensity, which includes sound intensity, is the watt per square metre. Decibels are often used instead of watts/m or pascals. The logarithmic nature of the decibel scale enables values to be expressed in a much more compact form. It is much easier to discuss sound intensity in a logarithmic scale (in decibels), than using exponential notation involving micro units to many thousands of units. A 10-fold (10 x) increase in sound intensity is represented by an increase of 10 dB. An increase of 3 dB equates to a doubling of sound intensity, and is about the smallest change in sound intensity that can be detected by a human ear.

46. The human ear can perceive a vast range of sound intensities, from very faint to extremely loud. A linear scale to represent this range would be unwieldy. The way humans perceive loudness is also logarithmic. A 3 dB difference is probably just noticeable; a 10 dB increase in sound level is generally perceived as roughly as a sound that is twice as loud. Each 10 dB increase represents a tenfold increase in sound intensity (power). The decibel scale is often referenced to a standard threshold of hearing (0 dB) or other specific reference levels depending on the context. Decibels are the standard unit for measuring sound pressure levels. However, the human ear does not perceive all frequencies equally.

47. Human hearing is not equally sensitive to all sound frequencies. People can hear between 20 Hertz and 20 kilohertz (kHz), but it is much more sensitive to frequencies in the 250-5,000 Hz range. “A-weighting” is a frequency weighting curve that modifies the measured sound pressure level to better match how

humans hear. A-weighting de-emphasises low and very high frequencies, to which the human ear is less sensitive, and gives more weight to mid-range frequencies. It helps to quantify noise levels in a way that correlates more closely with how humans experience and perceive loudness and potential hearing damage.

48. The human ear is more sensitive to sound in the 1 to 4 kHz frequency range than to sound at very low or very high frequencies. C-weighting (dB(C)) is a frequency weighting which emphasises lower frequencies compared to A-weighting. It is less sensitive to high frequencies and more sensitive to low frequencies than A-weighting. It is used in sound level measurements to assess the impact of low-frequency sounds, particularly for peak sound pressure measurements, like impulse noise. It is essentially a flat response across a range of frequencies (31.5 Hz to 8 kHz), making it suitable for measuring sounds where low frequencies are prominent or where sudden, loud noises (like gunshots, explosions or machinery) need to be evaluated for their potential to cause hearing damage.

The Anatomy and Functioning of the Ear

49. The pinna (or auricle) is the visible, cartilaginous part of the ear that helps to capture and localise sound. It is shaped to direct sound waves into the ear canal, and its curves and folds can slightly amplify certain frequencies. The ear canal (or external auditory meatus) is the narrow passage that directs the sound waves from the pinna to the eardrum. It also contains glands that produce earwax, which helps to protect the ear canal and eardrum. The fundamental frequency of the human ear canal, acting as a closed-end resonator, is typically around 3,000 Hz to 4,000 Hz. The eardrum (or tympanic membrane) is located at the end of the ear canal. The eardrum is a thin, sensitive membrane that vibrates when sound waves reach it. These vibrations are the first step in the process of converting sound waves into signals that the brain can interpret.

50. The middle ear's primary role is to amplify and transfer airborne sound vibrations from the eardrum to the fluid-filled inner ear. It acts as a mechanical transformer, efficiently converting sound waves in the air to vibrations in the inner ear's fluid. Sound waves travel down the ear canal and cause the eardrum to vibrate. The vibrations of the eardrum are transferred to three tiny bones in the middle ear, collectively called the ossicles (malleus, incus, and stapes). These bones act as a lever system, amplifying the vibrations. The malleus (hammer bone) is in part embedded in the tympanic membrane.

51. The middle ear's key function is “impedance matching”. The eardrum and ossicles transfer sound energy from the air (where there is low impedance) to the fluid-filled inner ear (with high impedance). Without impedance matching, much of the sound energy would be reflected back, and hearing would be greatly reduced. The stapes (stirrup bone), the last of the ossicles, connects to the oval window by its footplate. The stapes footplate sits on a membrane in the oval window of the cochlea and transmits sound, rather like a piston, to the cochlea, the fluid filled organ of hearing. The amplified vibrations of the ossicles cause the oval window to vibrate.

52. The tympanic membrane is about 20 times the size of the stapes footplate. The ossicular chain has a mechanical advantage in transmission from sound waves in the outer ear to the oval window. The round window of the cochlea has a reciprocal action to the oval window and allows movement of fluid within the inner ear. The middle ear also contains muscles that contract in response to prolonged loud sound, reducing the transmission of sound, to help protect the inner ear from damage. This is known as the acoustic reflex. Two small muscles are found within the middle ear cleft; the stapedius is attached to the stapes and when tense, can reduce the movement of the stapes footplate; the tensor tympani is attached to the malleus and can stiffen the ossicular chain and change the compliance of the tympanic membrane.

53. The middle ear is air filled. The Eustachian tube, which opens into the middle ear, is responsible for equalising the pressure between the air outside the ear and that within the middle ear. This allows movement of the tympanic membrane when it is vibrated by an airborne sound wave.

54. Sound waves enter the inner ear and then pass into the cochlea. The cochlea is filled with a fluid that moves in response to the vibrations from the oval window. The cochlea is shaped like a coiled shell (and is named after the Greek word for "snail"). When stretched out, it is approximately 30 mm in length. It is widest (about 2 mm) at the point where the basal coil opens into the vestibule, and it tapers until it ends blindly at the apex. Within it are 3 fluid filled compartments, the scala vestibuli, the scala media and the scala tympani. A stiff 'basilar' membrane runs the length of the cochlea. In humans the basilar membrane is about 30 to 35 mm in length. It widens from less than 0.1 mm near its basal end to 0.5 mm near the apex.

55. The organ of Corti sits on the basilar membrane and is the organ responsible for converting vibrations into electrochemical signals. Attached to the basilar membrane are inner hair cells (IHC). The stereocilia (hairs) of the inner hair cells are embedded in a second membrane running the length of the cochlea, the tectorial membrane. It is the relative movements of the basilar membrane and the tectorial membrane as they vibrate, that ultimately stimulate the sensory hair cells. The shape of the cochlea and length of the stereocilia are such that different parts of the cochlea respond to different frequencies of sound, rather like the keyboard of a piano. A certain degree of tuning is provided in the structure of the cochlear duct and its contents. With greater stiffness and less mass, the basal end is more attuned to the sounds of higher frequencies. Decreased stiffness and increased mass render the apical end more responsive to lower frequencies.

56. Sound energy can also reach the cochlea by bone transmission. The cochlea is embedded in very dense bone of the skull base. Very loud sound can reach the cochlea by direct transmission through the bones of the skull, and through the teeth. Sound energy can reach the inner ear directly bypassing the outer and middle ears.

57. The inner hair cells are connected to the neural pathway, such that when the stereocilia of the IHC bend, an electrical stimulus is transmitted through the neural auditory pathway. To talk about the "tuning of the cochlea" is probably an oversimplification; the neural pathways in the cortex of the brain further map

sounds and change sounds resulting in the perception of hearing. There are three rows of outer hair cells (OHC). These are also attached at their base to the basilar membrane and have stereocilia which are embedded in the tectorial membrane. The function of the OHC is to respond to sound by enhancing the vibration of the membrane, and so acting as an amplifier within the cochlea. Adjacent to the hair cells are various structural supporting cells.

58. Synapses are specialised junctions where nerve cells (neurons) communicate with each other or with other cell types like muscle or gland cells. They act as transmission points, relaying signals through the nervous system. These signals are typically transmitted via chemicals called neurotransmitters, which diffuse across a small gap, the synaptic cleft, between the neurons. Synapses in the auditory pathway are crucial for relaying and processing sound information. They facilitate rapid and precise transmission of sound signals from the inner ear to the brain, enabling accurate sound localisation and perception. Different types of synapses are specialised to handle specific aspects of auditory processing.

59. The auditory nerve, also known as the vestibulocochlear nerve, is responsible for transmitting sound information from the inner ear to the brain. It acts as a vital communication channel, in the pathway that converts sound vibrations into electrical signals that the brain can interpret as sound. The auditory nerve carries auditory signals from the cochlea (inner ear) to the brainstem, specifically the cochlear nuclei. These electrical signals travel along the auditory nerve to the brain (primary auditory cortex in the temporal lobe), where there is processing of auditory information interpreted as sound.

Hearing Loss

60. Hearing loss may be mild, moderate, moderately severe, severe or profound. It can affect one ear or both ears and leads to difficulty in hearing conversational speech or loud sounds. According to the WHO, small changes in hearing can change the classification of hearing loss from mild (26 to 40 dB) to moderate (41 to 70 dB), moderate to severe (71 to 95 dB), or severe to profound (over 95 dB). However, a 30 dB change within normal hearing (-10 to 20 dB) does not alter its descriptor.

61. The measured hearing thresholds are a proxy measure of hearing ability. The level at which hearing loss becomes noticeable varies between individuals. Hearing loss can occur for specific frequencies, such that part of the hearing may be normal, and other parts of the hearing (such as low or high frequencies) may be impaired. In general, in the perception of speech, vowel sounds are low frequency sounds, whereas consonants are high frequency sounds.

62. The main causes of hearing loss in adults are age-related sensorineural hearing loss, chronic diseases, smoking, otosclerosis and sudden sensorineural hearing loss. Other causes that can occur throughout life are impacted ear wax, trauma to the ear or head, loud noise/loud sounds exposure, exposure to ototoxic medicines or chemicals, nutritional deficiencies, viral infections and other ear conditions, delayed onset or progressive genetic hearing loss. Individuals vary in their response to factors such as age change, exposure to ototoxic drugs and infectious diseases.

63. Sensorineural and conductive hearing loss are two distinct types of hearing impairment, differing primarily in the location and nature of the problem. Sensorineural hearing loss can result in a loss of both volume and clarity, with sounds often perceived as muffled or distorted. Although sensorineural hearing loss can fluctuate in a few conditions, it can generally be considered to be permanent.

64. Conductive hearing loss occurs when sound waves are unable to reach the inner ear due to an issue in the outer or middle ear, while sensorineural hearing loss arises from damage to the inner ear (cochlea) or the auditory nerve and auditory cortex. Mixed pattern hearing loss occurs when there is both a sensorineural and an additional conductive hearing loss in the same ear.

Noise Damage and Noise Induced Hearing Loss ("NIHL")

65. Noise damage is a dose dependent condition. The Noise Immission Level (NIL) is an estimation of an individual's lifetime exposure to noise. It is a measure of lifetime noise 'dose' and is dependent on the average daily (8 hours) personal noise exposure level (lep,d) and the number of years of exposure at that level. It follows that the louder the noise and/or the longer the duration of exposure, then the higher the NIL will be. NIL = (Average daily noise level) + (10 x log10 T) where the average daily noise level is measured in "dB (A) lep,d" and "T" is time (in years). So, for instance, if someone was exposed to a daily noise level of 90 dB (A) lep,d, then to achieve an NIL of 90 dB (A) NIL would require only 1 year. If an individual was exposed to an average daily noise exposure of 90 dB for 10 years, his component NIL would be 100 dB(A)NIL.

66. An increase of 3 dB in the NIL equates to a doubling of the noise exposure of an individual, and an increase of 6 dB in the NIL is a nine-fold increase in noise exposure. The difference between a NIL of 90 db(A) and 100 dB(A) equates to a very significant difference in noise exposure (greater than 27-fold). It is accepted that individuals with hearing that is more sensitive than the 'average' person may sustain noise damage at a NIL of 90 dB(A). Around 50% of 'average' individuals will sustain noise damage at an exposure of 100 dB(A)NIL.

67. The response of the human auditory system to the effects of noise varies widely from one person to another. Not only does the susceptibility of the ear to loud sounds vary, but the audiometric pattern and the effects of noise exposure vary widely too. Due to its acute and cumulative effects on the cochlea, noise damage is a dose dependent effect, manifesting its effects in proportion to the total dose. The damage to the ear, the pattern of audiometric change and the effects of hearing loss vary, depending on the type and extent of noise to which an individual is exposed.

68. Noise-induced sensorineural hearing loss occurs when loud sounds damage the structures of the inner ear, specifically the hair cells and auditory nerve and pathways. This damage can be caused by a variety of insults from a single exposure to an extremely loud noise, to prolonged exposure to loud noises over time, or to a mixture of acoustic insults.

69. There are pathological differences in the pattern of damage caused by exposure to repetitive chronic steady-state broadband noise, and the damage caused by impulsive noise and acoustic trauma. It is accepted that exposure to loud steady-state broadband noise over extended periods of time, typically industrial noise, results in damage to the outer hair cells (OHCs) in the cochlea that respond to frequencies at, and adjacent to, 4 kHz. The damage is dose dependent and varies from one individual to another. As a secondary consequence of the loss of the OHCs, there is neuronal and synaptic change in the auditory pathway.

70. It is also acknowledged that there can be damage in the cochlea to the OHCs that respond to very high frequencies, those higher than 8 kHz. With prolonged exposure, there is OHC death and other damage to the inner hair cells (IHCs), resulting in a dead zone in the cochlea. The hearing loss that can be detected through audiometry, is primarily due to the loss of the cochlear amplifier effect of the OHCs. The damage to the OHCs is probably from hypoxia, and it is thought to initiate programmed cell death (apoptosis) of the outer hair cells.

71. The damage to the cochlea from intense impulsive noise and acoustic trauma is different. In addition to the outer hair cell damage, there may be structural damage to other parts of the cochlea including the inner hair cells and the supporting cells of the organ of Corti. The organ of Corti may become detached from the basilar membrane. There can in some cases also be damage to the ear drum and ossicular chain. Intense impulsive noise is often of short duration, and the lag in the initiation of the protective effect of the acoustic reflex may not allow protection of the cochlea from the full impulse of noise energy.

72. The pattern of sensorineural hearing loss is affected by the susceptibility to loud noise of the individual. The pattern of hearing loss is also affected by the level of noise, its duration, and whether or not the acoustic reflex is effective. The consequences of sensorineural hearing loss are dependent upon the degree and frequency range of the hearing loss.

73. Noise-induced hearing loss ('NIHL') is hearing loss from exposure to loud sounds. This damage can be temporary or permanent, depending on the intensity and duration of the noise exposure. Hearing loss can result from damage to structures and/or neural pathways that respond to sound. This type of hearing loss, termed "noise-induced hearing loss," is usually caused by exposure to excessively loud sounds and cannot be medically or surgically corrected.

Age Associated Hearing Loss

74. Changes in the inner ear that can affect hearing are common in an ageing population. Presbycusis (age associated hearing loss) develops slowly over time, making it difficult for individuals to notice the hearing loss initially. It generally affects both ears, leading to a symmetrical decline in hearing ability. Presbycusis often affects the ability to hear high-pitched sounds, such as those produced by women's and children's voices, or the ringing of a telephone. Communication and speech perception can be impacted especially in background noise.

75. Age-related changes in the middle ear and complex changes along the nerve pathways from the ear to the brain can also affect hearing. Some medical

conditions more common in an ageing population can also play a role. In addition, some genes make some people more susceptible to hearing loss as they age.

76. In general, age associated hearing loss causes gradual deterioration in sensorineural function, usually greater at high frequencies than at low frequencies. The pattern and extent of age associated hearing loss varies from one individual to another and is different in men and women. It is generally accepted that the hearing of men deteriorates with age at a faster rate than the hearing of women.

Tinnitus

77. Tinnitus is a condition where an individual experiences sounds, like ringing, buzzing, or hissing, in the ears or head, when there is no external source for those sounds. It can be symmetric, asymmetric or unilateral. The perception can vary from constant and unrelenting tinnitus to intermittent and occasional tinnitus. The severity can range from slight to catastrophic. Noise exposure is the commonest known pathological cause of tinnitus.

78. There is a relationship between the perception of tinnitus, its severity and its significance for mental health conditions. Severe and unrelenting tinnitus can lead to mental health breakdown, and suicidal ideation although tinnitus at this level of severity is rarely seen in clinical practice. Likewise significant mental health issues can result in an exacerbation of the symptoms of tinnitus.

79. Tinnitus is most commonly seen in individuals with hearing loss, although it also occurs in individuals with normal hearing. Tinnitus is reported to occur in up to 15% of individuals. The presence of tinnitus has been reported progressively to increase with age, affecting 5% of individuals 20 to 30 years of age and 12% of individuals above 60 years of age. Tinnitus can be seen in age-related hearing loss, conductive hearing loss from any cause (but most often resulting from otitis media and otosclerosis), exposure to ototoxic drugs, ionising radiation, or an ear injury.

Testing for Hearing Loss

80. Three types of testing are considered here.

81. First, Pure-tone audiometry ("PTA"). PTA is a behavioural test used to measure hearing sensitivity. This measure involves the peripheral and central auditory systems. Pure-tone thresholds (PTTs) indicate the softest sound audible to an individual at least 50% of times a tone is presented. It is a measure of hearing acuity but not a measure of audibility. Most audiometric tests are based on volunteered responses; the subject presses a button when a tone is heard.

82. In the UK, guidance published by the British Society of Audiology (BSA) sets out the recommended procedure. The Guidance covers the audiometric equipment, calibration, the audiometric test environment, preparation of test subjects, earphones and test time. The subject's response to the test tone should clearly indicate when the test tone is heard and when it is no longer heard. The

response system should be inaudible, with a response button connected to a signal light the preferred method.

83. The test starts with the better-hearing ear (according to the subject's account) and at 1000 Hz. Then 2000 Hz, 4000 Hz, 8000 Hz, 500 Hz and 250 Hz are tested in that order. Then, for the first ear only, 1000 Hz is retested. If the retest value is no more than 5 dB different from the original value, the more sensitive threshold is taken as the final value, but if the retest value differs from the original value by more than 5 dB then the reason for the variation should be investigated. Where needed and practicable, testing is also performed at intermediate frequencies 750 Hz, 1500 Hz, 3000 Hz and 6000 Hz (3000 Hz and 6000 Hz are usually tested in cases of high-frequency hearing loss but it is not a requirement for them to be tested). Testing then follows in the opposite ear in the same order.

84. The interval between the presentation of test tones should be varied between 1 second and at least 3 seconds. The tester must ensure that the timing of each tone is not predictable; random variations in durations are intended as a check against false positive responses. It is important that the tester does not stop the signal as soon as the subject responds, signals must be of the full duration, and the subject must respond throughout each one.

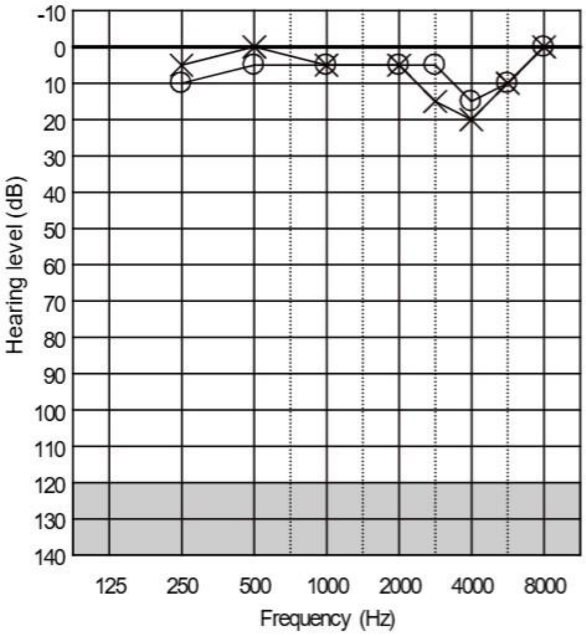
85. Threshold is defined as the lowest level at which responses occur in at least half of a series of ascending trials with a minimum of two responses required at that level. The test proceeds to the next frequency, starting at a clearly audible level (e.g. 30dB above the adjacent threshold), and the 10-dB-down, 5-dB-up sequence is followed until the threshold criterion is satisfied. The thresholds are recorded in a format that is recommended in the BSA Guidance. Red circles are used to mark the air conduction thresholds for the right ear, and a blue cross for the left ear.

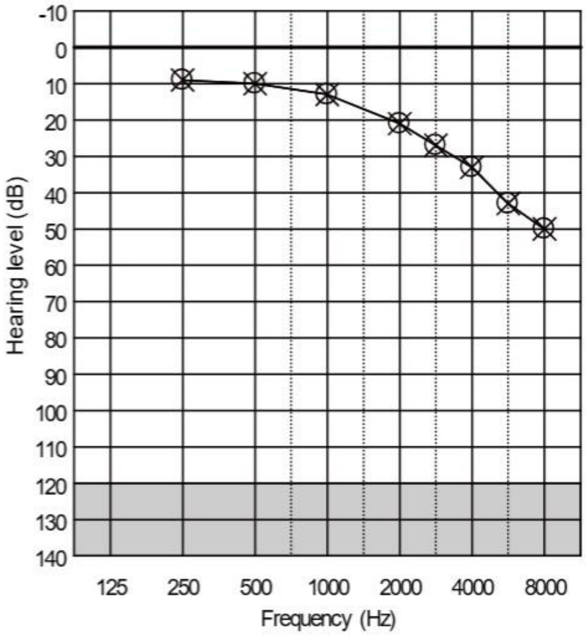
86. The BSA also sets out Guidelines for the use of pure tone audiometry in surveillance (occupational) testing. (Recommended Procedure Surveillance Audiometry BSA 2023). This does not involve bone conduction testing. The BSA recommended procedure for pure tone audiometry (2018) does not cover screening or automated audiometry. It does set out standards for testing, including the calibration of equipment, and the permitted ambient noise levels. The test starts with the better-hearing ear (according to the subject's account) at 1000 Hz. Next, testing of 2000 Hz, 3000 Hz, 4000 Hz, 6000 Hz, 8000 Hz, and 500 Hz should be performed in that order. Not all occupational screening tests, including some performed by the MoD, include testing at 8 kHz.

87. The audiogram quantifies and displays visually a patient's degree and type of hearing loss (sensorineural, conductive, or mixed). Various causes of hearing loss may demonstrate characteristic patterns on the audiogram, making this testing modality critical for diagnostic purposes. Air conduction thresholds, determined during a pure-tone audiometry test using headphones or ear canal inserts, represent the softest sounds a person can hear through the ear canal, travelling through the outer, middle, and inner ear.

88. By way of illustration, I set out below two audiograms taken from Prof. Lutman's generic report. He describes them as follows: "*The example on the left shows a*

stereotypical pattern of mild NIHL in a person aged 25 years. The example on the right has been created for a man aged 70 years whose hearing thresholds follow exactly the pattern for AAHL at the 50th percentile...In other words, the second example has stereotypical AAHL with no NIHL."





89. The recorded thresholds are plotted in a standardised format. In the audiogram on the left above, at 250 Hertz, the quietest sound appropriately responded to by the subject in 50% of tone presentations (threshold) is 10 dB in the right ear and 5 dB in the left ear. In the audiogram on the right above, at 8kHz it is 50 dB in both ears. Intermediate thresholds are plotted. The form allows for recording of thresholds that are less than 0 dB. Some individuals can hear tones that are quieter than the audiometric standard (0 dB).

90. Second, bone conduction tests. These determine bone conduction thresholds which refer to the softest level at which a person can hear sounds transmitted through bone vibration through the skull, rather than through the air. This test mostly bypasses the outer and middle ear, allowing audiologists to assess the function of the inner ear and auditory nerve. Bone conduction thresholds are a crucial part of diagnostic audiometry and are used to diagnose different types of hearing loss.

91. Bone conduction thresholds stimulate both ears and it is not possible to determine which ear is responding to bone-conduction testing without performing masking. The response is from the better hearing cochlea. Bone-conduction should normally only be performed in the frequency range 500 Hz to 2000 Hz. Testing is not recommended at frequencies below 500 Hz. Bone-conduction tests above 2000 Hz can be problematic due to transducer limitations and calibration issues and are not routinely undertaken.

92. Bone conduction audiometry is not as accurate as air conduction audiometry, and there is often a small difference in recorded thresholds. Bone conduction may result in artefactual thresholds.

93. Third, cortical-evoked response audiometry (‘CERA’). CERA is an objective hearing test that measures electrical activity in the brain's auditory cortex in response to sound stimuli. It is used when there are concerns about the reliability of other hearing tests or when assessing hearing in individuals who may not be able to provide reliable behavioural responses, such as infants, young children, or those with cognitive or physical impairments. CERA helps determine hearing thresholds and identify non-organic (factitious) hearing loss components.

94. CERA is conducted by placing electrodes on the scalp, typically on the forehead and behind the ears, to record brainwave activity. The patient listens to sounds, usually clicks or tone bursts, and the resulting electrical responses are analysed to detect the thresholds at which the brainwave activity in response to a click is lost. It helps determine the extent and nature of hearing loss, especially when other tests like pure-tone audiometry are inconclusive or unreliable. It can help to verify PTA responses. It can help identify cases where hearing loss is exaggerated or not genuinely present (non-organic hearing loss).

95. CERA is a valuable tool for assessing hearing, particularly when traditional methods are not suitable or reliable. It provides objective information about how the auditory system is responding to sound. Unlike pure tone audiometry it does not require the patient's active participation or cooperation. It is often performed in conjunction with the Pure Tone audiogram to validate the volunteered responses.

Calculating Hearing Loss

96. Hearing loss is only ever estimated and cannot be precisely calculated. Standardised tables of the hearing loss expected for age and gender are consulted. From these an age associated hearing loss audiogram is created. In a medicolegal context it is a hypothecated ‘but for noise damage’ audiogram. This is used to compare the hearing thresholds recorded during testing of the subject. The left and right ears are assessed separately, and the recorded thresholds compared with the hypothecated age associated audiogram. The way in which the hearing thresholds of a Claimant are estimated and the hypothecated age associated audiogram is constructed and compared with the measured hearing thresholds varies, depending on the method of assessment used. The hypothecated age associated comparator can only ever be an estimate.

97. The international standard ISO 1999:2013 utilises noise level and duration separately to predict the NIHL that would occur in populations exposed to combinations of noise level and duration (i.e., it does not utilise NIL). ISO 1999 provides a method for predicting the expected distribution of NIHL at the audiometric frequencies between 0.5 and 6 kHz. It also provides a formula for combining the effect of noise with age-associated hearing loss.

98. It is generally agreed that the hearing thresholds in the better hearing ear determine hearing impairment more than the hearing threshold in the worse

hearing ear. As such, the binaural hearing loss estimate is calculated based on the sum of 4/5 of the noise induced hearing loss estimate in the better hearing ear and 1/5 of the noise induced hearing loss estimate of the worse hearing ear. In military noise damage, significant hearing asymmetry is common, if not the norm. In selected cases a small binaural estimate can significantly underrepresent the damage to hearing of the individual.

99. The total hearing loss will be determined by all of the causes of hearing loss. This will include age associated hearing loss, noise induced hearing loss and hearing loss from any other cause. The determination of the noise induced hearing loss component varies depending on the methodology employed.

Hearing Protection

100. Hearing protection works by creating a temporary conductive hearing loss. This reduces noise exposure by physically blocking or absorbing sound waves before they reach the inner ear. Hearing protection may be more effective at preventing some frequencies of noise from reaching the inner ear to a greater extent than others.

101. Hearing protection falls into two classes: physical barriers and electronic noise cancellers. The former class includes earplugs, devices made of foam, silicone or other materials which are inserted into the ear canal to create a seal that blocks sound, and earmuffs, devices which cover the entire outer ear with padded cups, creating a barrier against noise.

102. The latter class includes Active Noise Cancellation (ANC) devices. This technology uses microphones and speakers to create a sound wave that is 180 degrees out of phase with the incoming noise, effectively cancelling it out. Hearing Enhancement Protection Systems combine noise reduction with the ability to amplify low-level sounds, allowing users to hear important sounds while still protecting their hearing from loud noises. Attenuation Hearing Protectors reduce the intensity of sound waves before they reach the eardrum.

103. Frequency-specific attenuation offers flat attenuation, meaning they reduce noise equally across all frequencies, preserving sound quality. Level-dependent protectors allow quiet sounds to pass through while blocking loud sounds, which is useful in environments with intermittent loud noises.

Audiology and Auditory Perception

104. The following basic principles, which were not covered to this depth in the judicial primer, were agreed between Profs. Moore and Lutman. It is convenient to set out these matters here.

105. Air-borne sound generally has to pass through the ear canal and middle ear in order to reach the inner ear (cochlea), where it is transduced into neural signals that pass via the auditory nerve to the brain. The ear canal acts as a resonator leading to a resonance centred slightly below 3 kHz on average in humans. Therefore, sounds near that frequency are transmitted with greater amplitude to the inner ear than at other frequencies. As a consequence, when exposed to

broadband noise, the region of the cochlea that at high levels responds most strongly to frequencies near 3 kHz tends to receive the highest level of stimulation and hence tends to accrue the most damage when noise levels are excessive. Because the cochlea responds nonlinearly, due to a mechanism known as the cochlear active mechanism, damage to the region of the cochlea responding to about 3 kHz leads to loss of sensitivity to low-intensity sounds at about 4 kHz; the level-dependent shift corresponds to a ratio of 4:3. This explains the well-known audiometric characteristic of NIHL produced by broadband noise with levels up to about 110 dB(A): the "4-kHz notch". The 4-kHz notch describes the characteristic shape of plotted threshold levels on an audiogram.

106. The main mechanism for NIHL as revealed by the audiogram is loss of outer hair cells in the cochlea. There may also be damage to the synapses connecting the inner hair cells to the auditory nerve and damage to the auditory nerve fibres themselves.

107. It has been recognised for decades that impulsive noise tends to be more damaging than steady noise having the same overall energy. The original version of ISO 1999 suggested an uplift of 10 dB for impulse noise, while the 1990 version suggested an uplift of 5 dB. However, the current (2013) version is silent on the issue. ISO is working on a new version of the standard, which may include an adjustment based on kurtosis (see below), although that addition has proved controversial among national standardisation bodies.

108. Kurtosis is a statistical measure that has been used to represent the impulsiveness of a noise. It can be applied to noise exposures consisting of a mixture of impacts or impulses and steady noise, as might occur for example in metal working workshops. In the opinion of Profs. Moore and Lutman, there is sufficient scientific evidence to support the inclusion of kurtosis as a measure for the prediction of NIHL.

109. Military noise exposure may include unprotected exposure to high-intensity impulses, for example from firing rifles or machine guns. In such cases, mechanisms of NIHL may be somewhat different from those occurring for less impulsive noise.

110. Observational studies suggest that the frequency of maximum NIHL in military cases tends to be higher than 4 kHz in many cases. Therefore, the mechanism of damage may not be the same in all respects for steady sound of moderately high level and impulsive sounds with very high peak levels. Partly, the difference may arise because the frequency spectrum of some military noises (e.g., rifles) contains substantial high-frequency energy. The reasons for the difference are not fully understood.

111. It is recognised that military noise exposure takes many forms other than discrete impulses, for example steady noise in military vehicles or aircraft, or workshop noise for military tradesmen.

112. In extreme cases of noise exposure, such as explosions very close to the individual, there may be traumatic damage to the ear causing hearing loss but such instances are rare and do not arise for decision in the present proceedings.

Sensitivity and Specificity

113. Any diagnostic test can be characterised by its sensitivity and specificity. Sensitivity is the ability to correctly identify true cases (true positives). Specificity is the ability to correctly identify true negatives, in other words freedom from false positives. To put it another way, sensitivity rules in a condition; specificity rules it out. If both sensitivity and specificity are known, it is possible to calculate a measure of discriminability, such as d' (d-prime). The higher the value of d', the better is the ability of the test to distinguish true cases from true negatives. For any given "discriminability", the ability of the test measure correctly to distinguish true positives from false positives, it is often possible for the test designer to adjust criteria within the test to promote sensitivity at the expense of specificity, or vice versa.

114. There is no "gold standard" for the diagnosis of NIHL. It is not possible to conduct a biopsy and determine by microscopic examination the presence of damage to an individual's hearing as an oncologist might look for cancer cells. It is not possible, ethically, to expose living persons to extreme noise and measure the damage to their hearing which follows. While the absence of a gold standard diagnosis makes estimation of sensitivity challenging, it can be demonstrated mathematically that, for a test with d' greater than zero, the proportion of positive diagnoses in a sample of people (who may or may not have the underlying condition) places a lower bound on sensitivity.

115. I return to the important issue of sensitivity and specificity in chapter 5 below.

PART 2 – THE GENERIC ISSUES

Chapter 4 – Acoustic Engineering Evidence

116. There is agreement between the parties on the subject of acoustic engineering evidence. The two experts instructed by the parties, Mr Kevin Worthington for the Claimants and Mr Timothy Ward for the Defendant, were instructed to provide evidence on "*the nature of any acoustic differences between the general kinetics of military noise and "broadband" industrial and or other noise, and any consequential impact on medical causation*."

117. The experts agreed that military noise exposure means exposure to noise whilst engaged in military service and that non-military noise exposure means any type of occupational noise exposure outside military service. They agreed that military noise exposure comprises exposure from sources such as weapons, explosives and similar, but also from activities such as travelling in, and working with, vehicles, engineering and maintenance work, work with powered and non-powered hand tools and ancillary equipment. They agreed that non-military noise exposure cannot be characterised monolithically as "broadband", "steady state" or "Gaussian" (or normal distribution). Non-military noise exposure, they say, has been shown to be of significantly varying temporal complexity (for example, as characterised by the kurtosis quantity).

118. Sources of exposure can vary significantly in frequency content, and any individual's exposure depends on the mix of sources – so the exposure may have any mixed-type of frequency content. They say that general military and general non-miliary noise exposure are distinctly different in terms of frequency content, total energy or temporal complexity.

119. The engineering experts also agree as to the definition of "impulsive sounds". They say these are characterised by the rise time, the maximum sound pressure reached (e.g. peak sound pressure level, or "Lcpeak"), duration ("the pressure envelope"), frequency content, and sound energy content (the sound exposure level "Lae"). The sound energy content of an impulse is related to peak sound pressure and duration. The experts explained that impulsive sounds are found in both military and non-military environments and that weapons and explosives tend to produce impulsive sounds. The character of weapons noise and impulsive noise can readily be measured and assessed.

120. The experts say that impulsive sounds from weapons used in the military environment presented higher sound levels than would typically be found in non-military occupational settings. In non-military environments, peak sound levels greater than around 135 dB are uncommon and greater than around 145 dB rare. By contrast in military environments, peak sound levels experienced from weapons and similar might range from around 145 dB to in excess of 175 dB, without accounting for any hearing protection worn. As an example, the person firing a service rifle such as the SA80 rifle might experience sound levels of about 146 dB (with blank rounds) and 157 dB (with live rounds). The sound energy from the impulse might be of the order of 110 dB (with a blank) or 124 dB (with live rounds). The impulsive sound from an SA80 rifle would be characterised as mid or mid/high frequency.

121. The experts also agree that personal hearing protection will reduce the level (magnitude) of sound presented to the wearer and alter its character (including frequency content). This is the case for both impulsive sounds and non-impulsive sounds. For impulsive sound a person wearing hearing protection would experience the impulse with lower peak sound level, and different duration and frequency content, compared to a person without hearing protection.

122. By a letter dated 14th November 2018 from the Government Legal Department, the Defendant made certain admissions about noise exposure levels caused by vehicles and equipment in the armed forces. Those noise exposure levels were set out in an appendix to the letter. The Defendant admitted that, insofar as the Court found that a Claimant was exposed to any source or sources of noise as set out in the appendix, without wearing any form of hearing protection, the Claimant was exposed to the noise admission value according to the variables set out in the appendix. Since it may be useful in other NIHL cases, I have appended a copy of that appendix to this judgment, marked as Appendix B.

123. It follows that no issues relating to acoustic engineering evidence arise for decision, although the evidence of the acoustic engineers underlies much of what follows.

Chapter 5 – Epidemiology, Sensitivity and Specificity

124. In this chapter I consider the epidemiological evidence and the related topic of sensitivity and specificity.

Epidemiology

125. Both parties commissioned statistical and epidemiological evidence. The Claimants instructed Prof. John Norrie MSc, CStat, FRSE, FFPH, FSCT; the Defendant instructed Prof. Damien McElvenny PhD CStat HonFFOM. Prof. Norrie is a medical statistician specialising in randomised clinical trials and observational studies of drugs, devices and complex interventions and assessing the quality and weight of epidemiological evidence; and Prof. McElvenny is a biostatistician and occupational epidemiologist specialising in research into the effects of people's work on their health. Neither of them was called to give evidence because they were substantially in agreement and their individual and joint reports were put into evidence by agreement.

126. They agreed that hearing loss affects around 11 million people in the UK and increases with age; and around 1 million people are estimated to have severe or profound levels of deafness. Exposure to noise (both occupational and/or non-occupational) can cause noise-induced hearing loss. There is, they said, "*considerable variability across the source and duration of the noise as to magnitude of the effect, and also considerable variability between people as to whether they are affected and by how much*". Many risk factors appear to influence hearing loss in addition to age. These include medical conditions such as diabetes and hypertension, chemotherapy, some types of antibiotics and heart drugs, smoking, ototoxic chemicals (e.g., solvents, heavy metals), and genetics, as well as noise in certain industries and non-occupational noise. There is no objective diagnosis or "gold reference standard" for the determination of noise-induced hearing loss in either military or other occupational or environmental settings.

127. There are, I am told, "*various diagnostic performance metrics*" (e.g., including sensitivity and specificity) which quantify a diagnostic test's ability to correctly assign an individual's status as diseased or not diseased. These diagnostic performance measures focus on true positives, true negatives, false positives and false negatives. It is agreed that sensitivity and specificity are inter-related. I am told that "*it makes little sense to present either without the other*". As sensitivity rises, specificity will tend to fall: "*you can create a diagnostic rule that captures all cases with military noise-induced hearing loss by, say, putting the diagnostic threshold low enough, but at the expense of also declaring many without the disease as (false) positives i.e., low specificity*. And vice versa: "*you can successfully identify all those without military noise-induced hearing loss, but at the expense of only capturing a low number of cases (low sensitivity*)."

128. Professors Norrie and McElvenny tell me that where "*the trade-off between sensitivity and specificity is optimised can be assessed numerically using a conventional Receiver Operating Characteristic (ROC) analysis but is better informed by considering the context of the diagnostic test and the costs (financial*

and human) and consequences of the respective false positive and false negative misclassifications."

129. There are many checklists available for the assessment and critical appraisal of diagnostic test studies, as reporting is frequently inadequate. However, they all include three critical questions; namely (i) is this study valid? (ii) does the diagnostic test under assessment accurately distinguish between people who do and do not have the specific disorder? And (iii) can this valid, accurate diagnostic test be applied to a specific patient?

130. In practice, a number of questions need to be asked about a diagnostic test:

(i) Was there an independent, blind comparison with a reference (gold) standard of diagnosis?
(ii) Was the diagnostic test evaluated in an appropriate spectrum of patients (like those a clinician would see in practice)?
(iii) Was the reference standard applied regardless of the index diagnostic test result?
(iv) Was the test validated in a second independent group of patients?

131. In the opinion of Professors Norrie and McElvenny, if "*the study being evaluated fails any of these four criteria, then it needs to be considered whether the flaws of the study make the results invalid*".

132. They also agree:

(i) An important diagnostic metric in the context of civil personal injury claims is the Positive Predictive Value or PPV of a test. If the PPV is greater than 0.5, then we can say that if an individual has a positive test, it is more likely than not (i.e., on 'the balance of probabilities') that the individual has the disease (e.g., military noise-induced hearing loss).
(ii) There is a difference between a diagnosis of hearing loss at a specific point in time (cross-sectional) e.g., on an audiogram in which a subject's hearing is compared with standard age-sex reference populations with normal hearing, and the longitudinal assessment where several audiograms within the same subject are compared to establish deterioration of hearing over time.
(iii) Cochlear synaptopathy (or 'hidden hearing loss') is a new concept in hearing loss that relates to hearing loss attributed to synaptic dysfunction (loss) in the cochlea (the loss of nerve connections between the sensory cells and the brain). A feature is that the hearing loss, causing problems for example in listening and understanding speech, is not usually detectable on traditional hearing tests (audiograms). They agreed that this was a controversial topic, with differences of opinion around whether the animal studies and the small number of human studies are sufficient to establish that noise- induced synaptopathy (NIS) is a recognized state in humans. There do not appear to be any agreed diagnostic standards for NIS.

133. Prof. Norrie is of the view that in general, NIHL is established by review of patient history, a hearing test (usually an audiogram), and 'clinician assisting guideline' (e.g., CLB or Moore's M-NIHL). Prof. Norrie accepts that comparing the CLB

and one of the sequence of Moore's algorithms (e.g., the M-NIHL, rM-NIHL, or MLP-NIHL (the AI/ML-enabled version) in the absence of a gold / reference standard is challenging, but believes the studies, if dealing with an appropriate population (e.g., those likely to have M-NIHL, where the prevalence of M-NIHL among that population is > 50%) have shown the diagnostic performance of say MLP-NIHL is superior to CLB. However, he accepts that this is properly a matter for the Court to decide, and this is only an opinion based on Prof. Norrie's understanding of the comparison of two diagnostic approaches in the absence of a gold (reference) standard.

134. Prof. McElvenny says he did not assess Prof. Lutman's methodology in preparing his report. He said Prof. Moore did not follow the above methods for determining an acceptable diagnostic test. However, he says both Prof. Moore and Prof. Lutman regard their tests as being guidelines and so this renders assessment of specificity and sensitivity etc. somewhat moot.

135. The experts further agree that:

(i) Quantification of noise in terms of type, magnitude and duration – and cumulatively – appears to be challenging and that the effectiveness of protective equipment is limited.
(ii) Very few papers (including those by CLB and Moore on their respective NIHL algorithms) quantify statistical uncertainty around estimates i.e., typically done using 95% confidence intervals. This makes comparisons harder.
(iii) The reports in the literature seemed to be based on datasets that were taken as they were, from what was available. There are few, if any papers, where either pre- specified sample sizes calculations were completed or where a specific objective with a specified hypothesis was identified. Furthermore, identification of how many participants or exposures or outcomes will be needed to give a study adequate power to detect an effect if it exists (or dismiss an effect if it does not) is often not undertaken.
(iv) Since military cohorts are intensively screened at recruitment to ensure good hearing at the time of enlistment (and regularly throughout employment to maintain employment), the ideal comparator cohort for estimating differences to a cohort exposed to military noise would be one that had undergone screening identical to that which resulted in successfully joining and continuing in the military, but who then did not experience the exposure to military noise. This naturally is very difficult to achieve in practice, and none of the published studies in the extant literature claim to have attempted this by design. They say that what "confounding" you cannot address by design in these observational studies (e.g. as above, or by various forms of matching 'cases' to 'controls', for example) you must try to address by analysis, to reduce as much as possible the confounding. (I understand "confounding" here to refer to circumstances where the relationship between an exposure and an outcome is distorted, masked, or confused by an outside factor.) In general, the identified studies at most would try to adjust for age and sex; but for example a wider set of potential confounders (including perhaps diet, exercise, alcohol, smoking, education level, socio-economic status; and then genetic factors, or exposure to

ototoxic drugs, chemicals – and so on, around the issue of individual susceptibility) does not routinely appear to have been considered.

(v) In general, the degree of noise induced hearing loss in an age-sex matched population is considerably higher in the subset of people who join the military compared with the wider population that they are drawn from.

(vi) As to acceleration, they agree that this appears to be a controversial issue, for which there is not unanimous agreement. The orthodox view is that damage (hearing loss) is co-incident (or say within 3 weeks) to the noise exposure. However, some studies appear to show that military noise can 'accelerate' age-related hearing loss over a longer period. Many years after the exposure, a military noise exposed person may seem to have greater age-related hearing loss than for a similar person not so exposed. These studies however seem to be mainly cross-sectional, and it is recognised that high-quality longitudinal studies are needed, with appropriate adjustment for potential confounders and adequate size, when estimating the differences between exposed and non-exposed, and assigning any difference to such 'acceleration'.

136. Prof. Norrie was of the view that in terms of the ISO guidelines, the two algorithms appear to utilise different standards – Moore favouring ISO 7029 (2017) and CLB favouring ISO 7029 (1984). There are discussions around which standard uses the more appropriate, up to date data on normative population-level statistical distributions of hearing levels. ISO 7029 (2017) has itself had an update last year (2024) to improve some of the data utilised.

137. Prof. McElvenny was of the view that Prof. Lutman preferred the comparator population that was contemporaneous (both in terms of potential time period of exposure and ages at which hearing loss was assessed) with the population of Claimants in the class action. That reduces the impact of time-related and age-related effects on the comparison between the test and the control population.

138. Given the level of agreement between Professors Norrie and McElvenny, no issues directly relating to epidemiological evidence arise for decision, but it is convenient to consider here the related topic of sensitivity and specificity.

Sensitivity and Specificity

139. Sensitivity and specificity are measures of the performance of a diagnostic test. Sensitivity refers to the ability of a test to correctly identify a true positive. The sensitivity figure gives the proportion of cases with noise-induced hearing loss that are correctly diagnosed as having noise-induced hearing loss. For example, if a diagnostic test with a sensitivity of 0.7 (70%) was applied to 100 individuals who actually *have* noise-induced hearing loss, it would *correctly* produce a *positive* diagnosis for 70 individuals.

140. Conversely, specificity refers to the ability of a test to correctly identify a true negative. The specificity figure gives the proportion of cases without noise-induced hearing loss that are correctly identified as not having noise-induced hearing loss. For example, if a diagnostic test with a specificity of 0.7 (70%) was applied to 100 individuals who *do not* actually have noise-induced hearing loss, it would *correctly* produce a *negative* diagnosis for 70 individuals. The corollary

is that the test would have *incorrectly* produced a *positive* diagnosis for 30 individuals. The proportion of incorrect positive diagnoses equates to the false positive rate (in this example, it would be 30%). Hence, the false positive rate expresses the same statistic as specificity, but simply from the reverse perspective.

141. During the hearing, it became clear that the key battleground between the parties on this issue was as to which of two diagnostic methods, CLB and rM-NIHL, was the more robust and the more appropriate, but the issue is relevant to all diagnostic methods. All the various methods are described in detail in chapter 8.

142. It might have been thought that the resolution of this issue would have been critical in determining the principal issues in dispute in this case; regrettably that proved not to be the case. However, it is necessary to address this issue at this early point in the analysis.

143. The two epidemiology experts provided written evidence on the role of sensitivity and specificity in diagnostic tests. They agreed that sensitivity and specificity must be considered together, and that it makes little sense to present one without the other.

144. That too was the view of Prof. Moore and Prof. Lutman. The broader picture for legal claims is set out by Prof. Moore in Moore and Schlittenlacher, "Diagnosing Noise-Induced Hearing Loss Sustained During Military Service Using Deep Neural Networks", 2023 ("the Moore MLP(18) 2023 paper"):

> If a diagnosis is made in the context of a claim for compensation for NIHL …then it is important to achieve high sensitivity, so as to avoid unfairly denying compensation to an individual who does have M-NIHL [military noise-induced hearing loss]. However, specificity should be sufficiently high to avoid compensation being given to a high proportion of individuals who do not have NIHL.

145. Another point of agreement concerned the absence of a gold standard that can definitively diagnose whether an individual has noise-induced hearing loss. Without a gold standard, it is difficult to estimate the sensitivity of a test because uncertainty remains as to whether, when the test produces a positive diagnosis, it is indeed correct because the individual does in fact have noise-induced hearing loss. There was less agreement regarding the extent to which the absence of a gold standard affects specificity. In Prof. Lutman's individual generic report, he contended that the estimation of specificity is much simpler and can be achieved by applying the test to people who have not been exposed to noise. Conversely, in Prof. Norrie's individual report, he suggested that Lutman et al., "Guidelines for Diagnosis of Noise-Induced Hearing Loss and Their Specificity", 2024 ("the Lutman 2024 paper") illustrates the difficulty of no established gold standard when trying to estimate the specificity of the rM-NIHL method. In his individual report Prof. McElvenny said that no great weight can be put on both the sensitivity and (where present) specificity calculation in the absence of a gold standard.

146. A final general point of agreement concerned the holistic approach to diagnosing noise-induced hearing loss. The epidemiology experts recognised in their joint report that both Prof. Moore and Prof. Lutman regard their tests as being

guidelines, and so this renders assessment of specificity and sensitivity somewhat moot.

147. Before considering the figures, it is helpful to explain some of the terms used.

148. MilDB and ContDB stand for 'military database' and 'control database' respectively. Moore et al., "Modification of a Method for Diagnosing Noise-Induced Hearing Loss Sustained During Military Service", 2022 ("the Moore rM-NIHL 2022 paper") explained that the military database, comprising men who had been on active duty in the British military and were claiming compensation for M-NIHL, was used to evaluate sensitivity. Specificity estimates were obtained using a German control population from von Gablenz & Holube, "Hearing threshold distribution and effect of screening in a population-based German sample", 2016 ("the von Gablenz 2016 study") which had been screened to exclude significant noise exposure. These databases were randomly split into two: MilDB1 and ContDB1 were used to develop the rM-NIHL method, while MilDB2 and ContDB2 were used for evaluation of the method. However, the authors of the Moore rM-NIHL 2022 paper also used MilDB1 and ContDB1 to assess these figures.

149. *d'* (also known as 'd-prime' or the 'discriminability index') measures the ability of the test to distinguish two cases, i.e. whether noise-induced hearing loss is present or not. Prof. Moore explained that the higher the value of d', the better the discriminative performance of a test. It is calculated from the proportion of "hits" (cases of noise-induced hearing loss that receive a positive diagnosis) and the proportion of "false alarms" (cases without noise-induced hearing loss that receive a positive diagnosis).

Professor Moore's Figures

150. There was a significant discrepancy between the specificity figures produced by Prof. Moore and Prof. Lutman for the various diagnostic methods.

151. Prof. Moore's figures for the M-NIHL and rM-NIHL methods were published in the Moore rM-NIHL 2022 paper. His figures for the CLB method were found in his individual generic report. His figures for the MLP(18) method, purports to make a a diagnosis "for the individual" were published in the Moore MLP(18) 2023 paper. They are as follows:

Table 1. Results for the rM-NIHL method using MilDB2 (noise-exposed database) and ContDB2 (non-noise-exposed database)

	Sensitivity	**Specificity**	***d'***
Either ear	0.979	0.630	2.37
Both ears	0.761	0.946	2.32
Each ear separately	0.870	0.788	1.92

Table 2. As Table 1 but for the M-NIHL method

	Sensitivity	**Specificity**	***d'***
Either ear	0.993	0.402	2.21
Both ears	0.880	0.815	2.07
Each ear separately	0.940	0.609	1.83

Table 3. As Table 1 but for the CLB method

	Sensitivity	**Specificity**	***d'***
Either ear	0.83	0.83	1.92
Both ears	0.55	0.96	1.88
Each ear separately	0.69	0.86	1.58

Table 4. As Table 1 but for the MLP(18) method

	Sensitivity	**Specificity**	***d'***
For the individual	0.986	0.902	3.49

Table 5. As Table 1 but rM-NIHL using MilDB1 and ContDB1

	Sensitivity	**Specificity**	***d'***
Either ear	0.972	0.613	2.20
Both ears	0.769	0.914	2.10
Each ear separately	0.871	0.763	1.85

Table 6. As Table 5 but for the M-NIHL method

	Sensitivity	**Specificity**	***d'***
Either ear	0.993	0.344	2.06
Both ears	0.930	0.828	2.42
Each ear separately	0.961	0.586	1.99

152. It was also noted that previously in Moore and von Gablenz, "Sensitivity and specificity of a method for diagnosis of military noise-induced hearing loss", 2021 ("the Moore and von Gablenz 2021 paper"), Prof. Moore's figures for the M-NIHL method were as follows:

Table 7. M-NIHL method's sensitivity and specificity, as per the Moore and von Gablenz 2021 paper

	Sensitivity	**Specificity**	***d'***
Both ears	0.97	0.67	2.3

153. Prof. Lutman, in his individual generic report, stated that Prof. Moore had confirmed in correspondence that the false positive rate for the M-NIHL method when only one ear is required for an overall positive diagnosis was 43% (i.e. specificity of 0.57). This was agreed by Prof. Moore in oral evidence.

154. Furthermore, Prof. Moore relied on his figures of the positive predictive value ("PPV") of his three methods in the Moore MLP(18) 2023 paper, which are as follows:

Table 8. Positive predictive values (PPV) for different assumed prevalence levels

Method	Assumed prevalence	PPV
M-NIHL (2020)	0.9	0.937
rM-NIHL	0.9	0.960
MLP(18)	0.9	0.989
M-NIHL (2020)	0.5	0.625
rM-NIHL	0.5	0.683
MLP(18)	0.5	0.910
M-NIHL (2020)	0.25	0.356
rM-NIHL	0.25	0.469
MLP(18)	0.25	0.770

155. PPV represents the likelihood that an individual genuinely has the condition (here, noise-induced hearing loss) if the test gives a positive diagnosis. Thus, the PPV figure focuses on positive results, whether true or false. In the absence of a gold standard diagnostic measure, the PPV depends on the assumed prevalence (i.e. what percentage of individuals are assumed to genuinely have noise-induced hearing loss). For example, an assumed prevalence of 0.5 (i.e. 50%) means that it is assumed that, in a cohort of 100 individuals, 50 genuinely have noise-induced hearing loss. According to the Moore MLP(18) 2023 paper, while prevalence is of course unknown, it is likely to be reasonably high – and almost certainly above 0.5 – for a cohort of military Claimants. Altogether, using the example of rM-NIHL with a PPV of 0.683 for an assumed prevalence of 0.5, the PPV means that 68% of the individuals who receive a positive diagnosis are individuals who genuinely have noise-induced hearing loss (i.e. 68% of the positives are true; 32% of the positives are false). It is said in the Moore MLP(18) 2023 paper that a PPV value greater than 0.5 (i.e. 50%) indicates that the balance of probabilities is met. The two epidemiology experts agreed with this threshold in their joint report.

Professor Lutman's Figures

156. Prof. Lutman's figures concerned the false positive rate (i.e. specificity), which were published in the Lutman 2024 paper. The relevant statistics for our purposes are as follows:

Table 9. False positive rates for men aged 18-50

	UK-NSH	NHANES	NHS Clinic
CLB	31%	26%	23%
M-NIHL	66%	66%	77%
rM-NIHL	53%	41%	67%

Table 10. False positive rates for men aged 18-80

	UK-NSH	NHANES	NHS Clinic
CLB	33%	29%	35%
M-NIHL	72%	71%	89%
rM-NIHL	59%	48%	80%

157. The Lutman 2024 paper describes the three databases: UK-NSH, NHANES, and NHS Clinic. The first two are retrospective; the final one is prospective. UK-NSH stands for the UK National Study of Hearing, which was a large-scale multi-centre population study carried out in several phases between 1979 and 1986. NHANES stands for the National Health and Nutrition Examination Survey from the USA. It was the audiometric examination data from the 2015-2016 cohort that was used in the Lutman 2024 paper. The NHS Clinic data comprised audiograms obtained in an NHS audiology department as part of routine clinical patient care.

158. In addition, Prof. Lutman, in his individual generic report, provided his false positive rate figures for the MLP(18) method based on the UK-NSH and NHANES datasets.

Table 11. False positive rates for the MLP(18) method

	UK-NSH	NHANES
The cohort without noise exposure	52.6%	56.9%
Men aged up to 50 (within the cohort without noise exposure)	37.7%	37.9%
Men with an average hearing threshold level across 0.5, 1, 2 and 4 kHz of at least 10 dB in the better ear (within the cohort without noise exposure)	92.6%	89.5%

159. For context, the final category of men with an average hearing threshold level across 0.5, 1, 2 and 4 kHz of at least 10 dB in the better ear is said to represent individuals who have meaningful hearing loss. According to Prof. Lutman, the significance is that all Claimants who bring a claim are very likely to have this level of hearing loss at least. Thus, the MLP(18) method would struggle to distinguish the Claimants who have hearing loss that is not due to noise exposure (i.e. it would give a positive diagnosis to the vast majority of individuals with meaningful hearing loss, regardless of their noise exposure history).

Criticisms of Professor Moore's Figures

160. Prof. Moore's emphasis on the sensitivity figures was subject to the qualification, acknowledged even by himself in the Moore rM-NIHL 2022 paper and reaffirmed in oral evidence, that it had to be assumed that the military Claimant database genuinely all had noise-induced hearing loss (following screening based on the

individuals' medical history). Prof. Lutman, in his section of the joint report, highlighted the flawed logic involved in assuming that military Claimants genuinely had noise-induced hearing loss. He posited that, in an extreme example where a test simply gave a positive outcome regardless of input, the sensitivity would be 1.0 for any sample even if it contained no true positive cases. He also contended that Prof. Moore's assumption was not reasonable because the most common form of sensorineural hearing loss is idiopathic (i.e. where the cause of hearing loss is simply unknown or inconclusive).

161. Prof. Moore was challenged on his specificity figures as well, especially in relation to the MLP(18) method. Prof. Moore's figures in Table 4 were significantly different to Prof. Lutman's in Table 11. Prof. Lutman's explanation for the discrepancy is that the MLP(18) method is designed to distinguish military Claimants from non-claimants (i.e. the German control population from the von Gablenz 2016 study), which is the reason for the high specificity as assessed by Prof. Moore. However, the MLP(18) method is not equipped to distinguish noise-induced hearing loss from other forms of hearing loss within a group of military Claimants, which is the reason for the low specificity (i.e. high false positive rate) as assessed by Prof. Lutman.

162. The issue of false positives for age-associated hearing loss was put to Prof. Moore. Based on its own analysis of the MLP(18) method, the Defendant suggested that a male aged 60 at the 40^{th} percentile (i.e. 60% of the population has better hearing) for age-associated hearing loss solely would receive a result of 0.565 from the MLP(18) method, and therefore a positive diagnosis for noise-induced hearing loss (because it is above 0.5). In his oral evidence, Prof. Moore took the view that, if that person had a history of noise exposure, then it would be more likely than not that they had noise-induced hearing loss.

163. Prof. Lutman challenged Prof. Moore's reliance on the PPV figures too. In his view, for the PPV to be meaningful, it must be calculated with respect to discrimination of positive and negative cases in a single source population. But Prof. Moore draws on two different populations.

Criticisms of the Lutman 2024 Paper

164. Before turning to the criticisms of each comparator group, two general points were accepted by Mr Green during cross-examination regarding the Lutman 2024 paper, of which he was a co-author. Firstly, the focus in the military context should be on the figures for ages 18-50, rather than 18-80. Secondly, the figures in the Lutman 2024 paper were based on an either-ear diagnosis (i.e. the worse-hearing ear in cases of asymmetrical hearing loss) for the rM-NIHL method. In contrast, in its application of the CLB method, the Lutman 2024 paper reached a positive diagnosis based on either both ears or the better-hearing ear only, even though the CLB method permits either-ear diagnosis. Therefore, Mr Green acknowledged that, if the criteria for the rM-NIHL method required a diagnosis on the basis of both ears, the false positive rate would be low.

165. As to the comparator groups, the two epidemiology experts agreed that the ideal comparator cohort for estimating differences in a cohort exposed to military noise would be one that had undergone screening identical to that which resulted in

successfully joining and continuing in the military, but who then did not experience the exposure to military noise. However, this is very difficult to achieve in practice, and no published studies claim to have attempted this by design. The three comparator groups used in the Lutman 2024 paper are addressed in turn below.

a) UK-NSH

166. Prof. Moore's primary criticism of the UK-NSH data was that it was too old. In his section of the joint report, Prof. Lutman expressed the view that there was a lack of evidence that the hearing of the population as a whole has improved over the past four decades. However, the Lutman 2024 paper itself had recognised that there may have been changes in population characteristics since the data was obtained during the 1980s. Prof. Lutman accepted in cross-examination that evidence does exist to suggest that factors which would have an adverse effect on people's hearing are decreasing and, as a consequence of that, the population levels of hearing have improved. Likewise, Mr Green accepted that the UK-NSH dataset is the least applicable of the three datasets due to potential improvements in the general population since the 1980s, although he maintained that it was not entirely without merit. Indeed, Prof. Moore accepted in cross-examination that UK-NSH had actually been used in his preferred 2017 dataset (ISO 7029:2017/2024) for age-associated hearing loss, although he stressed that it only formed a very small part of the overall 2017 dataset.

167. Prof. Moore's other key criticism was that some of the population in the UK-NSH comparator group probably had noise exposure sufficient to produce noise-induced hearing loss because the screening criterion for the noise immission level (i.e. an estimation of an individual's lifetime exposure to noise) was 97 dB(A), which is sufficient to produce noise-induced hearing loss in more noise-sensitive individuals. However, Prof. Lutman rebutted this criticism in two ways. First, his view, as the lead member of that study and holder of the data from that study, was that contamination by individuals with noise-induced hearing loss was unlikely as there were very few cases that were even close to that 97 dB(A) threshold. Second, in any event, the Lutman 2024 paper had assessed the false positive rates on more strictly screened UK-NHS data, and it yielded very similar percentages to the overall UK-NHS data.

168. Prof. Moore's final criticism was that the population probably included individuals who had hearing loss at an early age, unlike former military personnel who are screened to have normal hearing at the time of entry to military service. The premise of this criticism was contradicted by Prof. Lutman, who said in oral evidence that the military entry requirement for hearing levels in fact would permit some quite substantial hearing loss.

b) NHANES

169. The false positive rate for rM-NIHL based on an either-ear diagnosis was 41% in the Lutman 2024 paper, and between 37% and 39% in the Moore rM-NIHL 2022 paper (see Tables 1 and 5 above). Putting aside the small difference between the figures, Prof. Moore identified two drawbacks to the NHANES comparator group.

170. Firstly, it was uncertain whether the NHANES comparator group had screened out individuals with conductive hearing loss. The Lutman 2024 paper itself addressed this point by explaining that the NHANES comparator group screened out individuals on the basis of a recordable acoustic reflex (i.e. a contraction of muscles in the middle ear in response to noise to help protect the inner ear), which ensured that conductive hearing loss was effectively eliminated. In oral evidence, Prof. Lutman argued that the acoustic reflex is a more sensitive indicator of conductive hearing loss than comparing air conduction and bone conduction thresholds. He also expressed the view that the acoustic reflex allows 5-10 dB of conductive hearing loss, compared with Prof. Moore's opinion that the figure was 10-20 dB.

171. Secondly, it was likely that the NHANES comparator group contained a material proportion of noise-exposed individuals. In his section of the joint report, Prof. Lutman maintained that the screening criteria would have excluded anyone with material noise exposure. Furthermore, even if there had been tighter screening as suggested by Prof. Moore, Prof. Lutman considered that it would only have a marginal effect on the false positive rate.

c) NHS Clinic

172. Prof. Lutman said the NHS Clinic comparator group was the most appropriate because it involves people with hearing difficulties and/or tinnitus coming forward to a clinic seeking a differential diagnosis, in the same way as military Claimants would come forward to a medical examiner in personal injury claims seeking a differential diagnosis of noise-induced hearing loss.

173. Prof. Moore set out two criticisms of the NHS Clinic comparator group. First, he argued that the NHS dataset is inappropriate because the great majority of military Claimants did not have any hearing difficulty or tinnitus prior to their noise exposure. Prof. Moore agreed in cross-examination that military Claimants would come to a medical practitioner also complaining of hearing difficulty, but he maintained that the comparator group should not involve a population reporting hearing difficulty in order to be as closely matched as possible to the military Claimants, but for the noise exposure. The Lutman 2024 paper itself acknowledged that there are two possible approaches, namely whether the comparator group should comprise individuals reporting hearing difficulty (without a history of noise exposure) or not. The Lutman 2024 paper advocated for the former as more realistic in a medico-legal context, but indicated that both approaches led to similar conclusions in any event. Mr Green's opinion, in his section of the joint report, was that this was not a valid criticism and did not address the high false positive rate, especially in comparison to the CLB method.

174. Second, Prof. Moore cast doubt on the NHS Clinic comparator group because, in relation to the screening process, they did not state what questionnaire was used or what the specific exclusion criteria were. Mr Cox, in his section of the joint report, concurred that the absence of information on the NHS Clinic comparator group (other than that it was based on individuals with hearing loss) negates any conclusions that are made using that data. The Lutman 2024 paper itself, reaffirmed by Mr Green in oral evidence, made clear that those with a history of noise exposure or conductive hearing loss were excluded. As to noise exposure, Mr Green contended that it is entirely within their remit for clinical audiologists

to take a history of noise exposure from patients, and indeed they may have greater experience in doing so than a medical examiner.

175. In oral evidence, Mr Green went further and suggested that screening in the NHS Clinic comparator group was better than the German comparator group from the von Gablenz 2016 study used for the rM-NIHL method, which was based on a self-reported noise history instead. However, the criticism remained that the NHS Clinic comparator group failed to screen out potential causes of hearing loss other than noise (such as exposure to ototoxic substances or a history of familial hearing loss not caused by noise), which would have been screened out under the rM-NIHL guidelines. Prof. Lutman in cross-examination accepted that he had made an assumption that those with alternative causes of hearing loss would have been identified and screened out. Mr Green confirmed in cross-examination that alternative causes of hearing loss had not been excluded. His justification was that the cause of a lot of hearing loss is unknown. In any event, Mr Green pointed out that the German comparator group suffered from exactly the same problem.

The Parties' Submissions

Sensitivity and Specificity in General

176. The Claimants highlighted two general themes. The first was that specificity and sensitivity go hand-in-hand, which served as a constant underlying point to undermine the Lutman 2024 study (which addressed specificity only) and to endorse the rM-NIHL method with its greater sensitivity. The second was the centrality of the overall clinical picture to all of the diagnostic guidelines. Again, this provided a constant qualification to all the sensitivity and specificity figures, which are based solely on the audiometric pattern.

177. In contrast, the Defendant challenged the equivalence of specificity and sensitivity for the purposes of a Court determining a claim brought by former military personnel for two reasons. First, in the absence of a gold standard, it is in reality impossible to identify 'true positives' (and so sensitivity) with certainty. Second, a Court will invariably be faced with a Claimant who has a positive diagnosis, and the question then will be whether a Court can rely on that positive diagnosis as accurate. It is said, therefore, that the false positive rate (i.e. specificity) is far more significant in the context of military deafness legal claims.

178. The Claimants refuted the notion that the false positive rate is any more important than sensitivity in practice. They posited the following example in relation to rM-NIHL's 37% false positive rate for one-ear diagnosis. Assume a cohort of 100 soldiers who have developed hearing loss and who have been carefully screened so that all alternative plausible causes have been excluded. Assume that, after this screening, none of the 100 have been screened out, 50 actually have NIHL, and 50 have an idiopathic hearing loss (on the Claimants' case, an implausibly high proportion used purely for the purpose of this example). With rM-NIHL's assessed sensitivity of 98% and specificity of 63% (i.e. 37% false positive rate) as per Prof. Moore, the audiometric element of the test alone, with zero clinical judgement, will generate the correct result for 81 out of 100 of the cohort (49 true positives and 32 true negatives; 1 false negative and 18 false positives). A number of different variables leads to a higher percentage of correct results. If a positive diagnosis is required in both ears, then, again using Prof. Moore's assessed

figures, the total number of correct results is around 86 out of 100. If the ratio for the prevalence of noise-induced hearing loss is 75 with noise-induced hearing loss and 25 with idiopathic hearing loss (75:25), 90 out of 100 results would be correct. If the prevalence ratio is further increased to 90:10, then 94 out of 100 results would be correct. As such, through the worked example, the Claimants suggest that viewing the false positive rate by itself can lead to a misleading picture.

False Positive Rate of the rM-NIHL Method

179. The Defendant's overall submission was that the specificity of rM-NIHL is very considerably worse than that of CLB according to the Lutman 2024 paper (see Tables 9 and 10 above). rM-NIHL's false positive rate, therefore, is a further reason to prefer CLB over rM-NIHL.

180. The Claimants identified two systematic problems with the Lutman 2024 paper which, they submitted, comprehensively undermines the comparative specificity figures for the two methods.

181. The first was the different approaches to asymmetry in terms of an either-ear diagnosis for rM-NIHL, but a both-ear or better-ear diagnosis for CLB. The effect is to suppress the false positive rate for the CLB guidelines and to increase it for rM-NIHL. If the CLB method had been applied correctly based on an either-ear diagnosis, a false positive rate in the region of 40-53% (rather than 23-31% for men aged 18-50, or 29-35% for men aged 18-80) would have been expected based on Lie et al, "The Prevalence of Notched Audiograms in a Cross-Sectional Study of 12,055 Railway Workers", 2015 ("the Lie 2015 study") and Osei-Lah & Yeoh, "High frequency audiometric notch: An outpatient clinic survey", 2010 ("the Osei-Lah 2010 study"). Alternatively, if rM-NIHL had been applied to permit both-ear diagnoses only, its false positive rate would have been in the region of 6-9% (rather than 41-67% for men aged 18-50, or 48-80% for men aged 18-80) based on the Moore rM-NIHL 2022 paper (see Tables 1 and 5 above). Therefore, equalising the approach to asymmetry means that there would either not have been much difference between CLB and rM-NIHL in terms of false positives, or rM-NIHL would have performed better than CLB.

182. The second systematic problem, it is argued, is the different approaches to the TDH-39 earphone deduction. The Lutman 2024 paper applied the 6 dB deduction when applying CLB but not rM-NIHL, even though the deduction is not intrinsic to either method. The Lutman 2024 paper itself recognises that, by not applying the deduction, rM-NIHL's false positives rates were raised by about 16%. Thus, equalising the approach to the TDH-39 earphone deduction (for example, applying it to rM-NIHL, which would reduce its false positive rate by about 16%) would mean that there is not much difference in specificity between CLB and rM-NIHL.

183. The Claimants proceeded to submit that the three comparator groups used by the Lutman 2024 paper were inappropriate to assess the specificity of rM-NIHL and CLB. The Defendant's position was that the Court can place reliance on the analysis based on the three datasets, but even if that was not the case, any alleged drawbacks to the comparator groups applied equally to the CLB method, which nevertheless performed better than rM-NIHL at every turn.

184. The first comparator group is UK-NSH. The Claimants ultimately emphasised that the data was simply too old. In response, the Defendant argued that this submission must fall away given that it is used in the ISO 7029:2017 dataset. The second is the NHANES comparator group. The Claimants acknowledged that this was least objectionable of the three comparator groups, but still submitted that the slightly lower false positive rate in the Moore rM-NIHL 2022 paper should be preferred over the Lutman 2024 paper. In addition to the screening issues for NHANES, they put forward a positive case for the figures in the rM-NIHL 2022 paper on the basis that the German comparator population was carefully screened and closely matched to the noise-exposed population. The Defendant rejected the alleged screening issues as immaterial, and submitted that the closeness of the false positive figures between the Moore rM-NIHL 2022 paper and the Lutman 2024 paper actually serves to give validity to the latter.

185. The final comparator group is the NHS Clinic. On this occasion, it was the Defendant that put forward a positive case for the suitability of this comparator group in that it most closely replicated the task of identifying which of the individuals complaining of hearing loss have noise-induced hearing loss. The Defendant underscored that the NHS Clinic comparator group, while they reported hearing problems, had been screened to exclude noise exposure. In addition, it was irrelevant to criticise this comparator group on the basis that military Claimants had normal hearing prior to noise exposure, when military Claimants had not even been assessed by a medical examiner at that time and instead are assessed at the time when they are also complaining of hearing loss. Conversely, the Claimants' primary submission was based on Prof. Moore's criticism that the NHS Clinic comparator group failed to screen for alternative causes of hearing loss in the same way as the screening under the rM-NIHL guidelines. The Claimants also added, based on the Osei-Lah 2010 study, that the prevalence of unilateral notches appears to be particularly high (around 75%) in hearing clinics, which in turn exacerbated the first systematic problem of the different approaches to asymmetry.

Sensitivity

186. The Claimants submitted that the real difference between CLB and rM-NIHL was not specificity, but rather sensitivity. rM-NIHL had the advantage in ensuring that former soldiers who do genuinely have noise-induced hearing loss would not be deprived of compensation to which they ought to be entitled because the diagnostic method incorrectly identified them as negative (i.e. false negatives). The Defendant rebutted the Claimants' submission on both a general and specific level. Generally, it is said that Prof. Moore prioritises sensitivity over specificity because he adopts an ideological approach that is directed towards maximising compensation for hearing loss for the greatest number of Claimants. Specifically, the Defendant highlighted two problems with the sensitivity figures. Firstly, in the absence of a gold standard, the sensitivity figure does not actually mean anything. Secondly, in relation to the MLP(18) method only, the sensitivity figure was calculated based on a binary approach centred on 0.5, rather than 'grey area' approach between 0.44 and 0.56 that emerged in the course of Prof. Moore's cross-examination.

Professor Moore's Specificity Figures

187. The Defendant disputed the reliability of Prof. Moore's specificity figures both generally and specifically in relation to the MLP(18) method. On a general level, the Defendant used the example of the changes in Prof. Moore's specificity figure for the M-NIHL method between papers to suggest that it is difficult to have confidence in his figures. In relation to the MLP(18) method, the doubt cast over Prof. Moore's figures was reinforced by the substantial difference with Prof. Lutman's false positive rates based on two different population groups. The Defendant also reiterated the fact that the specificity figure, like the sensitivity figure, was calculated based on a binary approach centred on 0.5, rather than a 'grey area' approach. Lastly, the Defendant cited the yellow taxi/blue taxi fallacy in rejecting Prof. Moore's evidence that the hypothetical man aged 60 at the 40th percentile, with a history of noise exposure, is more likely than not to have noise-induced hearing loss.

188. The origin of the yellow taxi/blue taxi fallacy is the dissenting judgment of Brachtenbach J in Herskovits v Group Health Cooperative of Puget Sound (1983) 664 P 2d 474, a decision of the Supreme Court of Washington. It was adopted by Lord Phillips in the UK Supreme Court in Sienkiewicz v Grief [2011] 2 AC 229, 266F-267C (see also Baroness Hale at 290B-C):

> Brachtenbach J dissented. He warned against the danger of using statistics as a basis on which to prove proximate cause and indicated that it was necessary at the minimum to produce evidence connecting the statistics to the facts of the case. He gave an interesting illustration of a town in which there were only two cab companies, one with three blue cabs and the other with one yellow cab. If a person was knocked down by a cab whose colour had not been observed it would be wrong to suggest that there was a 75% chance that the victim was run down by a blue cab and that accordingly it was more probable than not that the cab that ran him down was blue and therefore that the company running the blue cabs would be responsible for negligence in the running down. He pointed out that before any inference that it was a blue cab would be appropriate further facts would be required as, for example, that a blue cab had been seen in the immediate vicinity at the time of the accident or that a blue cab had been found with a large dent in the very part of the cab which had struck the victim.

PPV and d-prime

189. In his oral evidence Prof. Moore had suggested that it would be reasonable, in borderline cases under what he regarded as the more robust and conservative rM-NIHL method, to go back to the M-NIHL method on the basis that its PPV is still greater than 0.5. Unsurprisingly, the Defendant rejected this as an unjustifiable circumvention of an unfavourable outcome from the rM-NIHL method. The Defendant criticised Prof. Moore's PPV figures for three reasons. First, the Defendant pointed to Prof. Lutman's evidence that the PPV should be based on single source population, rather than two different populations. Second, they argued that the PPV calculations depend on an 'assumed prevalence' of NIHL in the population of Claimants, which is unknown, unknowable and not actually relevant or applicable to any individual case. Third, they contended that Prof.

Moore's PPV calculations depend on his own calculations of sensitivity and specificity, which themselves are problematic. This final criticism was also levelled at Prof. Moore's d-prime figures. Those d-prime figures, in the Defendant's submission, were relatively close for the CLB and rM-NIHL methods in any event.

Discussion

190. I first address the Defendant's submission regarding rM-NIHL's false positive rates. The central question is how much weight, if any, ought to be attached to the false positive rates of rM-NIHL, especially when compared to those of CLB, in deciding which method ought to be preferred. The relevant statistics are as follows. For rM-NIHL, Prof. Lutman's figures for an either-ear diagnosis are 41% on NHANES, 53% on UK-NSH, or 67% on NHS Clinic (see Table 9). It should be noted here that I accept Mr Green's evidence that the focus should be on men aged 18-50, rather than 18-80. Prof. Moore's figures for an either-ear diagnosis are 37% (see Table 1) or 39% (see Table 5). In contrast, for CLB, Prof. Lutman's figures for a both-ear or better-ear diagnosis are 23% on NHS Clinic, 26% on NHANES, or 31% on UK-NSH (see Table 9). Prof. Moore's tables do not contain a better-ear category, but his figures for a both-ear diagnosis is 4% (see Table 3). If an either-ear diagnosis is adopted, as the Claimants submit to be the correct approach to CLB, Prof. Moore's figure is 17% (see Table 3).

191. On the face of it, the false positive rates of rM-NIHL appear unacceptably high (67% at the highest estimate), whether viewed as absolute figures or by reference to those of CLB. However, in my view, there are three main problems with attaching significant weight to these figures.

192. The first is the sheer range of figures that have been produced. There is a significant difference between rM-NIHL's highest figure (67%) and its lowest figure (37%). Likewise, CLB's figures range from 4% to 31%. In my view, there are simply too many disputed variables involved in calculating the relevant number to ground any decision confidently on a particular false positive rate. The key variables are whether the diagnosis is based on both ears and/or the better ear and/or either ear; whether the TDH-39 earphone deduction is applied or not; and the comparator groups used to assess specificity.

193. The first two variables seem straightforward in that it is ultimately the choice of the authors of the study, and the evidence is that these choices do make a difference. However, I shall comment on the final variable of the comparator groups in somewhat more detail in relation to the Lutman 2024 paper, especially given that the parties devoted significant time to this issue during the trial. I make clear from the outset that I do not regard any of the criticisms of the three comparator groups to be sufficiently compelling to render the figures from the Lutman 2024 paper in any way invalid or inappropriate. On the contrary, I consider Prof. Lutman's approach to the NHS Clinic comparator group to be the most sensible for the purposes of the medico-legal context here. That approach entails assessing specificity in respect of a group that is complaining of hearing difficulty but is screened for noise exposure, as opposed to one that has no such complaints (which is advocated by Prof. Moore in relation to the German comparator group from the von Gablenz 2016 study).

194. Given that it is intended to be applied to individual military Claimants, the crux of the specificity exercise is an assessment of how many false positives are produced amongst *the individuals who complain of hearing loss but who do not in fact have noise-induced hearing loss*. Thus, if I had to identify the comparator group on which most reliance could be placed, I would specify the NHS Clinic cohort as the best of the available options. I recognise that the NHS Clinic also produces the greatest difference between the false positive rates of rM-NIHL and CLB. However, for the reasons that I set out above regarding the other variables and the reasons that I shall proceed to now, my view on the most relevant comparator group ultimately does not make a material difference to my conclusions on specificity.

195. The applicability of the false positive rates to military Claimants brings me to the second problem, namely the absence of any "gold standard" diagnostic measure for noise-induced hearing loss. I appreciate that this problem poses an even greater challenge to the sensitivity figures, but it also affects the weight that I can attach to the specificity figures. To illustrate my point, I take the example of Prof. Moore's lowest false positive rate for rM-NIHL of 37% on the German comparator group, in which none of the individuals complained of hearing loss and therefore are less likely to exhibit audiometric hearing loss (on which both specificity and sensitivity figures are solely based). That is relatively straightforward because it is known for certain that they do not have noise-induced hearing loss because they have never been exposed to sufficient noise for noise-induced hearing loss to be plausible (unless they have not been truthful about their noise exposure history). I am doubtful, however, whether this 37% figure can reliably be transferred and applied to all the military Claimants, who are complaining of hearing loss and therefore, conversely, are more likely to exhibit audiometric hearing loss whether caused by noise or not.

196. The problem is compounded by the fact that, unlike the general population in the German comparator group who have never been exposed to military noise, it cannot be definitively be known (because there is no gold standard and they by definition all have some history of military noise exposure) which individuals among the military Claimants do *not* have noise-induced hearing loss, and therefore whether the false positive result is in fact correct. In other words, knowing that an individual does *not* have noise-induced hearing loss is a pre-requisite to classifying whether that individual has been *incorrectly* diagnosed as *having* noise-induced hearing loss. I accept that this means the false positive rates for rM-NIHL might well be an under-estimate which further supports the Defendant's position, but this reasoning applies equally to CLB.

197. I also acknowledge that the figures for the NHS Clinic (where the comparator group complained of hearing loss) might go some way to mitigating this issue. Nevertheless, the fact remains that the majority of the false positive figures derive from general population comparator groups, and so my concerns about the reliability of these figures when applied to military Claimants are not substantially assuaged.

198. The final and most fundamental problem, though, is that looking at specificity in isolation without sensitivity is meaningless or perhaps misleading. This is a point to which I shall return in detail regarding what seems to me the most suitable approach to all these statistics from a judicial perspective. At this juncture, it

suffices to say that, in my judgment, little weight should be attached to the false positive rates in determining whether rM-NIHL or CLB should be preferred.

199. I now turn to the Claimants' submission that sensitivity should be a reason to prefer rM-NIHL over CLB. There are, in my view, two major problems with this submission. The first is that it suffers from the same fundamental problem that sensitivity and specificity go hand-in-hand, and therefore to prefer one diagnostic method over another based solely on sensitivity would be erroneous.

200. The second problem relates to Prof. Moore's premise for calculating sensitivity that all (or the vast majority of) the military Claimants do in fact have noise-induced hearing loss. This assumption is deeply problematic because it assumes the very issue that the diagnostic method is designed to test. I do not express as strong a criticism of this assumption as it may at first glance warrant. The need for this assumption stems from the absence of a gold standard, and there was no suggestion in evidence of an alternative, let alone better, approach to assessing sensitivity. It is an obvious flaw to have to assume that *all* military Claimants have noise-induced hearing loss, but at the same time (and without reaching any conclusion at this junction) it does not seem outrageously far-fetched to me if it turns out that a high majority of them do, or at least not so far-fetched that I might feel obliged to disregard the sensitivity figures entirely. The extent to which they may have noise-induced hearing loss over and above the expected age-associated hearing loss, i.e. quantification, and indeed whether or not the Defendant may even be liable for any such damage are separate matters that should not be conflated with diagnosis.

201. Equally, for specificity, an assumption is made that *all* of the comparator group do not have noise-induced hearing loss, when in fact some of them might well do. People do not always tell the whole truth about their noise exposure history. What I find particularly troublesome, however, is the suggestion that those military Claimants who are not caught by the diagnostic method (i.e. false negatives) are therefore unfairly denied compensation, when it may be that the diagnostic method did not catch them because they do not in fact have noise-induced hearing loss – it was simply assumed that they do. In my judgment, either problem separately constitutes a fundamental flaw in the Claimants' submission, and *a fortiori* when they are viewed cumulatively. I reiterate, however, that I am not saying that the sensitivity figures should be disregarded entirely, but rather that the weight to be attached to the sensitivity figures should be even less than to the specificity figures.

202. My conclusion that little weight should be attached to the specificity figures and very little to the sensitivity figures means, in practical terms, that they should be simply considered as rough 'ballpark' estimates. These estimates only amount to suggesting that rM-NIHL is probably more sensitive and CLB is probably more specific, and no more than that.

203. I now set out what I consider to be the most suitable approach to all these statistics from a judicial (rather than scientific) perspective. The touchstone is that one must look at sensitivity and specificity hand-in-hand. This was the one point of unanimity across all the relevant experts, and it is therefore one to which I adhere firmly. Both parties' submissions, in my view, ultimately drifted too far from this mooring point. The practical importance of this approach was illustrated

perceptively by the Claimants, who provided the worked example of 100 screened military Claimants. I also find there to be some force in the Defendant's repeated theme that what matters for the medico-legal purpose is how a Court will determine a case when faced with a miliary-claimant who has a positive diagnosis under one of the diagnostic methods. Bearing these two points in mind, in my judgment, if any statistic should carry significance, it ought to be the percentage of positive results that are either true or false – in the experts' terminology, the PPV (positive predictive value). This is different to the false positive rate, which is the percentage of a cohort who do not have noise-induced hearing loss that are incorrectly diagnosed as positive (with the rest of that cohort being correctly diagnosed as negative).

204. There are two main advantages to the PPV. Firstly, it focuses on the positive results, which will invariably be under a Court's consideration because military Claimants are highly unlikely to bring a claim if they received a negative result. Secondly, it takes into account both sensitivity and specificity in its calculation, which upholds the touchstone of my suggested approach. Of course, there is the inherent and unavoidable issue that, on my own view, the sensitivity and specificity figures are 'ballpark' estimates, and so any errors in those figures will be carried over into the PPV. While this does concern me, I consider that the purpose of these calculations is as a safety net to ensure that neither method is producing an unreasonably high proportion of false positives by reference to the total number of positive results (both true and false).

205. To illustrate my point, I adopt the Claimants' worked example of 100 screened military Claimants, where 50 are assumed to have noise-induced hearing loss (i.e. an assumed prevalence of 0.5). For the present purposes, I adopt Prof. Moore's figures of 98% sensitivity and 63% specificity for an either-ear diagnosis under rM-NIHL (all figures are rounded to whole integers for convenience). Of the 50 *with* noise-induced hearing loss, there will be 49 true positives (i.e. 98% of 50) and 1 false negative. Of the 50 *without* noise-induced hearing loss, there will be 32 true negatives (63% of 50) and 18 false positives. That means there are 67 positive results in total, of which 49 are true (73%) and 18 are false (27%). In this scenario, therefore, around 27% of the positive diagnoses under rM-NIHL are likely to be false (a PPV of 0.73)[1]. In my view, this is more informative for a Court than knowing that the false positive rate is 37%.

206. Compare the same scenario for the CLB method, for which I take Prof. Moore's figures of 83% sensitivity and 83% specificity for an either-ear diagnosis. Of the 50 *with* noise-induced hearing loss, there will be 42 true positives (i.e. 83% of 50) and 8 false negatives. Of the 50 *without* noise-induced hearing loss, there will be 42 true negatives (83% of 50) and 8 false positives. That means there are 50 positive results in total, of which 42 are true (84%) and 8 are false (16%). In this scenario, therefore, around 16% of the positive diagnoses under CLB are likely to be false (a PPV of 0.83). Clearly, CLB's PPV percentage is better, which should be given some weight. I acknowledge that the difference between the two may

[1] The formula for calculating the PPV is set out in the Moore MLP(18) 2023 paper at page 6. Inserting the sensitivity (0.976) and specificity figures (0.639) from page 5 of that paper (both of which are slightly different from the Moore rM-NIHL 2022 paper at Tables 1 and 5) into the formula gives 0.730. However, the PPV given by Prof. Moore at Table 8 is 0.683. The reason for this discrepancy is unclear. Regardless of the precise figures, I use this exercise merely for illustrative purposes to explain the utility of the PPV figures.

well have been greater with Prof. Lutman's specificity figures instead, but I am cautious about using them when there are no counterpart sensitivity figures, which would contravene the touchstone of my approach.

207. The main objection to the PPV is the assumed prevalence, i.e. how many of the 100 people are assumed to have noise-induced hearing loss or not. The Defendant is correct that this cannot be known definitively. However, unlike the sensitivity estimates, it at least does not have to be assumed that there is a 100% prevalence. Instead, as in Table 8 above, different assumed prevalences can be used to make the calculation for a range of scenarios. For an assumed prevalence of 0.9 (i.e. 90 with and 10 without noise-induced hearing loss), rM-NIHL's PPV is 0.960 (i.e. of the positives, 96% are true and 4% are false). Using Prof. Moore's figures for CLB again (83% sensitivity and 83% specificity), CLB's PPV is 0.978. On that basis, the two methods are virtually the same. Conversely, for an assumed prevalence of 0.25 (i.e. 25 with and 75 without noise-induced hearing loss), rM-NIHL's PPV is 0.469. Using Prof. Moore's figures for CLB again (83% sensitivity and 83% specificity), CLB's PPV is 0.619.

208. In my judgment, rM-NIHL produces an unreasonably high percentage of false positives by reference to the total number of positive results when the prevalence is rather low, although I reject a fixed threshold of 0.5 (as discussed in the following paragraph). With the Osei-Lah 2010 study and Lie 2015 study in mind though (both their similarities and differences to military cases), it seems reasonable, out of the various assumed prevalences, to give the most weight to the PPV for the assumed prevalence of 0.5 as demonstrated in the preceding paragraphs.

209. I do, however, add one significant qualification to my discussion on the PPV, which is that I disagree with the majority of the relevant experts' view that a PPV greater than 0.5 satisfies the legal standard of proof in civil cases of the balance of probabilities. If true, this would mean that, of 100 positive results, 51 could be true and 49 could be false, but a Court should still be satisfied that an individual with a positive result is more likely than not to have noise-induced hearing loss. In my judgment, that cannot be correct. In this regard, I follow the rationale of the blue taxi/yellow taxi fallacy that the Defendant cited elsewhere in its submissions and was approved by the Supreme Court in Sienkiewicz v Grief [2011] 2 AC 229, namely that statistics of prevalence alone, without more, is insufficient to satisfy the balance of probabilities. I emphasise here that the PPV is only a helpful indicator for my present purposes of deciding which diagnostic method should be preferred, and not for deciding individual cases.

210. One final point concerns the holistic approach to diagnosis in both rM-NIHL and CLB. Even though I have concluded that the PPV figures are more helpful than either the sensitivity or specificity figures alone, this does not mean that I attach decisive weight to the PPV figures. That that approach is the right one is underlined by the fact that all these statistics depend on audiograms and all diagnostic methods are expressly intended as guidelines only. All require consideration of the whole clinical picture before reaching a diagnosis. As such, a positive or negative diagnosis, which informed the sensitivity and specificity estimates, may well be overturned by a medical practitioner in practice. In this light, it seems clear to me that these statistics should not be overly influential on, still less determinative of, my decision on the preferable diagnostic method.

Chapter 6 – Reliability of Military Audiograms

211. Much of the expert evidence in this case turns on the proper interpretation of audiograms. In this chapter I consider the reliability of audiograms generally and in particular those produced by the British military.

The Competing Contentions

212. The Claimants invite me to find that

- Military screening audiograms are inherently less reliable than Pure Tone Audiometry (PTA) conducted in compliance with the protocol and standards set by the British Society of Audiology (BSA);
- While military screening audiograms are suitable for screening and triage, they are not fit for diagnostic purposes, still less for the precise quantification of NIHL. They should carry limited weight outside their intended purpose;
- For the purposes of diagnosis and quantification of NIHL in an individual case, the Court should place little or no reliance on military screening audiograms unless, taken together, they demonstrate a consistent pattern;
- Military screening audiograms without the standard features of good audiometry practice – calibration records, the use of an acoustic booth, records of pre-testing ambient noise etc – are vulnerable to systematic error and should be considered even less reliable;
- Nonetheless, even from screening audiograms, it is possible to obtain a broad understanding of the hearing profile and trends of an individual where there is a consistent pattern in an audiometric series. This does not apply where the screening audiograms show significant and unexplained variation; and
- More generally, where possible, audiometry evidence (including BSA compliant PTA) should be considered in context and as a whole rather than in isolation.

213. The Defendant invites me to conclude as follows:

- Whilst initially there appeared to be a sharp divide between the Claimants and the Defendant over the accuracy and utility of military audiograms, by the end of the trial the distance separating the parties appeared to have narrowed. This was due to proper concessions made by the Claimants' experts;
- The correct approach to the use of military audiograms is to adopt a pragmatic view which requires an examination of relevant audiometric material collated over time and a willingness to use such records even with possible caveats. There is a legitimate presumption of accuracy, even though individual audiograms and individual readings at particular frequencies may have to be viewed with caution;
- The system which is operated by the MOD is designed to give a considerable degree of oversight over the hearing capacity of members of the armed forces. Whilst there may be operational failures which occur on occasion, the overwhelming majority of such audiograms are conducted

properly and in good faith. This is particularly so once a referral for medical assessment is made (as in *Lambie*);

- Where there is collusion between subject and operator in an attempt to "cheat" the audiogram, the results are usually obvious (*Lambie*).

214. As is apparent from the foregoing, it was common ground that clinical audiograms obtained by qualified audiologists using BSA-recommended methods provide the best evidence of hearing loss. However, the parties disagreed on the weight that the Court could place on screening or occupational health audiograms obtained during military service (or for that matter in other employment).

The Evidence

215. I heard from Major General Philip McNee, former Surgeon General to the United Kingdom Armed Forces. In his witness statement, he said that, by training, he was a radiologist but as Surgeon General he had been responsible, amongst other leadership roles, for medical policy and medical advice in the armed forces, including medical employment standards and clinical guidelines for operations and for setting medical training requirements. He made clear in his oral evidence, however, that he could only speak to the period 2008 to 2024 and that he had no specialist knowledge of audiometry.

216. In short summary, he said in his statement that the primary method for testing hearing assessment is through pure tone audiometry. Grading standards are clearly defined in the military: H1 requires cumulative scores of no more than 45 dB loss for both low and high frequencies; H2 permits up to 84dB for low tones and 123 dB for high tones; H3 and H4 represent progressively impaired hearing, with H8 indicating unfitness for service.

217. His statement emphasised the importance of equipment complying with BSA standards, annual calibration, and daily functional checks. It also details the criteria for diagnosing NIHL. He said that preventive measures had evolved to include baseline audiograms at recruitment, periodic surveillance based on exposure risk and enhanced precautions for individuals with confirmed NIHL. Medical staff are trained in accordance with BSA guidelines, and clear protocols govern referral thresholds and deployability assessments.

218. He said that the Ministry of Defence has maintained a robust and systematic approach to hearing conservation. Policies have been consistently updated to reflect best practice, ensuring that service personnel are protected through rigorous assessment, surveillance, and intervention measures.

219. He provided information about how audiometry is typically conducted, how military audiometry equipment is maintained and calibrated according to BSA standards and how medical staff who undertake audiometry are trained. He provided detail about the development of hearing surveillance and conservation measures.

220. Major General McNee was an impressive witness, but he was speaking at a very high degree of generality. This was not his specialism. He was not in post for much of the relevant period and he is not in post now. He could identify relevant

policies but could say little about how they were applied on particular occasions at particular locations.

221. There were certainly policy documents to support his general assertions about the adequacy of the military's policies. For example, Joint Service Policy ("JSP") 950, says that there are two kinds of military audiometry:

> Audiometry is undertaken in medical centres using automated pure tone audiometry. In this form it is equivalent to industrial screening audiometry. More accurate clinical audiometry is available in Service-approved audiology departments, such as the Defence Audiology Service (DAS) based at Institute of Naval Medicine.

222. JSP 950 continues:

> Noise Induced Hearing Loss (NIHL) may be suspected on the strength of screening audiometry results. However, because of the potential impact of the diagnosis on an individual's career and the potential liability issues, it should only be formally diagnosed by a Consultant in Occupational Medicine or Otorhinolaryngology (ORL) after "gold standard" clinical audiometry has been performed at an audiology department, such as the Defence Audiology Service (DAS) based at the Institute of Naval Medicine.

223. However sound was the *policy*, it is right to say that the documentation produced by the Defendant justifies some criticism of the *practice* of military audiometry. For example, from the introduction of JSP 950 onwards, there appears to have been a failure to measure 8 kHz thresholds. As the Claimants observe in their closing submissions, that was in breach of the '*Guidelines for undertaking screening pure tone audiometry'* which provides that "*the frequencies 500 Hz, 1 kHz, 2 kHz, 3 kHz, 4 kHz, 6 kHz <u>and 8 kHz</u> are to be recorded on every occasion for both ears*" (emphasis added.)

224. A research study conducted by the Defendant, the *"5 Scots study"*, demonstrated that screening audiometry was somewhat unreliable, in particular in relation to the higher tones:

> The 5 Scots study has been published as INM Report No. 2012.030. It has shown that the reliability of medical centre audiometry is poorer than that of the Defence audiologists, but that the difference is greater in the higher tones (which matter most) than the lower ones.

225. I was also referred to an Institute of Naval Medicine Report which compared the accuracy of medical centre audiograms against gold standard clinical audiograms conducted at the INM. It suggested that the medical centre audiometry was reaching very different results to the gold standard manual audiometry, with the medical centre audiometry frequently getting it wrong:

> Generally, the sick bay test has about 70% (60-80%) sensitivity and >90% specificity for old and new H grades. For the new N category, the sick bay test was only 49% sensitive and 76% specific.

226. However, I received very little evidence that spoke to how competently the military's screening tests were conducted in practice during the relevant period. Mr Silva and Mr Cox provided anecdotal, second hand, evidence of how well trained (or otherwise) certain unidentified medical staff were said to be. But I decline to place great weight on this sort of evidence which was little better than gossip.

227. There was little criticism in the evidence of the conduct of individual audiometric tests. With one exception, no lay witness, in the oral or written evidence I have seen, points to a deficiency in the way the audiograms were obtained. The one exception concerned Mr Lambie. He told me, and I accept, that he had 'faked' a single audiometric test in March 2011 with the complicity of the tester. He did so, he said, to ensure he was deployed to Afghanistan. He said he did this on a single occasion. Mr Green, the Defendant's expert, told me that this audiogram, "*the audiogram of 7/3/11"* was a *"complete outlier that is inconsistent with the audiometric series"*. That being so, he did not consider it further.

228. In his individual generic report, Prof. Moore suggested that there was, "*persuasive evidence to suggest that occupational audiograms obtained during military service are often unreliable*". However, that evidence was never identified and his criticism was more muted in the joint report. In that report he said that military service audiograms were likely to have been less reliable than clinical audiograms obtained by qualified audiologists. That seems to me undeniable.

229. In the joint report of the audiologists, Prof. Lutman maintained that occupational audiograms obtained during military service, when considered as a series over time, provided useful and apparently reliable contemporaneous evidence of hearing progression. He accepted that occasional rogue results occurred, but he contended that patterns across repeated tests allowed outliers to be identified and discounted.

230. Evidence on this subject also came from the two ear, nose and throat ("ENT") surgeons, Mr Cox and Mr Green. In their joint report, the ENT experts agreed that the screening audiograms may not be as accurate as diagnostic audiograms from specialist centres, and indeed they had both come across occupational screening tests that could not have been accurate. Importantly, however, they also agreed that screening audiometry cannot be disregarded on a generic basis. Their basic approach was that all available screening, clinical and medicolegal audiometry should be considered within the context of an audiometric series.

231. Mr Green, in his own section of the joint report, said that, unless there is a specific reason to disregard a series of occupational audiograms (for example, inconsistent fluctuations in hearing threshold levels), it should be considered a reliable record of an individual's hearing at the time of testing. In oral evidence, Mr Cox asserted that it is easy to spot an audiogram that is clearly inaccurate amongst a series, but he issued a caution that a single clearly inaccurate record does not necessarily mean that the rest of the series is accurate. I accept this evidence from the two ENT experts.

232. I am left with the clear impression that for the better part military screening tests were carried out conscientiously by appropriately qualified staff using adequate

equipment. But most of these were screening tests which did not satisfy the high standards set by the BSA and the reliance that can be placed on them is reduced accordingly.

233. It follows, that to a substantial extent, I accept the Defendant's submissions on this issue. My conclusions, against the evidential background set out above, are as follows:

(i) Pure Tone Audiometry (PTA) conducted in compliance with the protocol and standards set by the British Society of Audiology (BSA) is the gold standard of audiometric testing and should be used in medico-legal cases as the best evidence whenever it is available.
(ii) However, screening audiograms, including military screening audiograms, are ordinarily suitable for screening and triage. Furthermore, especially when they are part of a consistent pattern, they may also be used, as part of the exercise of clinical judgment by clinicians advising in medico-legal cases, for diagnostic and quantification purposes.
(iii) It may be possible to obtain from screening audiograms an understanding of the hearing profile and trends of an individual (in other words his auditory capabilities and the changes in those capabilities) where there is a consistent pattern in an audiometric series. That may not be possible where the screening audiograms show significant and unexplained variation.
(iv) Audiometry evidence (including BSA-compliant PTA) should, wherever possible, be considered in context and as a whole, rather than in isolation.
(v) The arrangements operated by the MoD are designed to give a good degree of oversight over the hearing capacity of members of the armed forces. The majority of such audiograms are conducted properly and in good faith. This is particularly so once a referral for medical assessment is made. However, there may, on occasions, be systemic or operational inadequacies, or even deliberate falsehood, and the Court should be alive to that possibility.

Chapter 7 - The Foundations

234. Underpinning the choice of diagnostic method, which I address in chapter 8, and the quantification of hearing loss, which I address in chapter 9, are a series of three discrete issues which were the subject of detailed evidence and submissions. Those issues are:

- The appropriate data to use when allowing for age associated hearing loss (AAHL);
- The need for "baseline correction";
- The possible effect of TDH39 headphones.

235. I deal with each in turn.

(i) The Appropriate Data to Use When Allowing for Age Associated Hearing Loss

236. A comparison dataset is required to estimate the age-associated hearing loss ('AAHL') of a given Claimant as part of the quantification of hearing loss. It is also relevant to diagnosis. In terms of comparison dataset, the evidence before the Court focused on the merits of ISO 7029:1984 (as amended in 2000) compared with those of ISO 7029:2017 (as amended in 2024).

The Respective Cases

237. The Claimants invites the following conclusions:

- For the purposes of both the diagnosis and quantification of NIHL, the Court should prefer ISO7029:2017 (as corrected in 2024) over the now obsolete ISO7029:1984/2000 standard.

238. The Defendant invites the Court to conclude:

- ISO 7029:1984/2000 standard is based on older data. Prof. Lutman considered it was reasonable to suppose that the underlying hearing ability of the population had improved somewhat in recent times (though it was difficult to be sure and this concession did not apply to 20-year-olds).
- Both the UK and the USA voted against the adoption of ISO 7029:2017 standard. Serious concerns were raised about its quality. Hundreds of corrections were made to it just seven years later, in 2024. It is based on heavily screened data and thus yields a rather idealised view of general population hearing. There is evidence that its estimates of AAHL do not fit well with the American and German screened populations. There is, as yet, no evidence to show that its AAHL estimates fit well with the UK population.

The Evidence

239. There have been two ISO International Standards concerned with the distribution of hearing thresholds as a function of frequency and age for populations with no significant noise exposure and no history of otological disorder. They are ISO 7029 of 1984 as amended in 2000 (hereafter "*the 1984/2000 standard*"), and ISO 7029 of 2017, with corrections in 2024 (hereafter

"*the 2017/2024 standard*"). Each describes "normal" hearing at different ages giving statistical reference data (describing the median and selected percentiles) for pure tone hearing thresholds in otologically normal adults separated by age and sex across selected frequencies. The 1984/2000 standard was based on the same data, which had been gathered in the 1950s to 1970s. The 2017/2024 standard was based on new data gathered between 1980 and 2012.

240. The differences between the 1984/2000 standard and the 2017/2024 standard are significant because the former provides a higher estimate of age associated hearing loss than the latter and so when deducted from current hearing loss produces a lower result.

241. The audiology experts disagreed about the best database for estimating age-expected hearing thresholds and the use to which that data should be put. For Prof. Lutman, AAHL goes solely to quantification. For Prof. Moore, it is an integral part of diagnosis as well as quantification. Prof. Lutman questioned aspects of the underlying datasets in the 2017 standard, including the exclusion of UK manual workers, and emphasised that it had provided increments relative to age 18 that needed offsets to reconstruct thresholds in dB hearing levels. He had suggested that population hearing may not have improved as much as claimed.

242. It was Prof. Lutman's view in his reports for this case that the Court should apply the 1984 standard, as he had done in the CLB method. He contended that there had not been significant improvement in hearing since the 1950s and that the paper on which the Claimants relied to argue for such improvement related to <u>unscreened</u> populations. Thus, the 'improvement' from previous generations could be explained by factors such as less noise exposure and might not be reflected, at least to the same extent, in a population <u>screened</u> to exclude noise exposure. He said in evidence that he accepted that the hearing of populations has improved, *"but I don't necessarily accept that the hearing of screened populations has improved to the same extent*".

243. Prof. Moore maintained that the 2017 standard had been appropriate in principle for quantifying expected age-related change and that subsequent corrections in 2024 had improved parameter tables. He cited evidence that hearing in the general population had improved across the decades, which had supported using mid-percentile baselines when quantifying NIHL.

244. Mr Cox dealt with this issue in his section of the joint report briefly. He favoured the ISO 7029:2017/2024 database, primarily because this data is contemporaneous with the current cohort of Claimants. He cited Kurakata, "*Re-estimated normal hearing threshold levels for pure tones using the calculation procedure of ISO 7029:2017*", 2023 ("the Kurakata 2023 study"). The Kurakata 2023 study concluded that its results supported previous studies suggesting that males in recent years retain better hearing than those in the past.

Discussion

245. The 2017/2024 standard was adopted as both a British Standard (by the British Standards Institute) and as a European Standard (by CEN, the *Comité Européen de*

Normalisation). The UK and the USA delegations raised objections to the 2017 standard when it was first introduced. No objections were raised when the standard was updated in 2024 because, on any view, the 2024 changes were necessary corrections. Prof. Lutman accepted in cross-examination that the UK had approved the consolidated 2024 standard without reservation. He went on to say that he did not "*have any great objections to this as a standard, in any case… Both the 2000 version of the standard and the 2017 version of the standard have some validity and I wouldn't have any strong objections to using … either version*".

246. It is fair to observe, as Mr Steinberg does in his closing submissions, that those answers represent a significant change in Prof. Lutman's stance. He had indicated in his generic report that he had strong objections to the 2017 dataset. In fact, Prof. Lutman made a number of concessions about these standards during cross-examination: he accepted that the hearing of the general population had improved "*to some extent*" between the time when the relevant population for the 1984 standard was tested and the time when the population for the 2017 standard was tested; he agreed in his generic report that it was generally "*correct to use contemporaneous data for comparison*"; he agreed in cross-examination that he would not try "to *defend the use of the 1984 standard*" ; and he agreed the 1984 data was "*out of date*". He further agreed that it would be a reasonable argument to advance that it would not be right to use pre-1980 data to quantify the claims for people in 2025.

247. In the light of that evidence, it seems to me that the only possible conclusion open to the Court is that, as the Claimants submit, for the purposes of both the diagnosis and quantification of NIHL, the Court must prefer the 2017/2024 standard over the now out-of-date 1984/2000 standard.

(ii) Baseline Corrections

The Competing Cases

248. The Claimants contend that:

- Where ISO 7029:2017 is used as a reference database, no 'baseline' adjustment is required.
- In the alternative, any baseline adjustment is, at most 2.4 dB, at all frequencies.

249. The Defendant invites the Court to conclude that:

- The weight of the evidence shows that a positive baseline correction is clearly required.
- That is so whether one is using 1984/2000 or 2017/2024.

250. The Defendant's primary position is that the Court should prefer the figures found in Lutman and Davis (1994) and used in CLB (2000). As an alternative, if the Court preferred a baseline correction that took into account other British studies, the figure would be an average of Lutman and Davis (1994), Davis (1995) and possibly Smith (1999). A further alternative would be the average corrections

that were subtracted from the various studies underpinning the 2017/2024 standard as representing the median HTLs of otologically normal 18-year-olds.

The Evidence

251. Prof. Lutman's evidence was that when first published in 1984, ISO 7029 defined median hearing threshold level at each audiometric frequency as the sum of a constant term representing hearing at age 18 and a function that depended on age. The constant term represented the median hearing threshold level of otologically normal persons aged 18. Values were not stated for the constant term although a note indicated that for practical purposes it might be taken to be 0 dB. He says that later scientific studies have shown that a non-zero constant was required to represent real populations. He referred to the constant term as an offset.

252. He said that the 2017 version of the standard defines "*the expected median value of hearing thresholds given relative to the median hearing threshold at the age of 18*". Working papers associated with that version gave some indication of what the offset might be. From the working papers behind the standard, it was possible to see that the magnitude of the offset for males for frequencies between 0.25 and 8 kHz the offsets range from 1.4 dB to 4.5 dB.

253. He said that the datasets used for the standard in 2017 were "*somewhat idealised*". The UK data was restricted to people with non-manual occupations although it has been shown that people for manual occupations have poor hearing even after excluding noise exposure.

254. Prof. Moore points to the youngest adult cohort in the 2017/2024 standard, showing a small positive deviation above 0 dB HL; on average ≈2.4 dB across 1–8 kHz. He regards this as a modest allowance for biological variability, warning that larger fixed uplifts risk obscuring genuine NIHL, particularly where military impulsive noise exerts greater impact at 6–8 kHz.

255. Prof. Moore is cautious about older or heterogeneous sources (e.g., Lutman & Davis 1994; Smith 1999; von Gablenz & Holube 2016; Zhang 2022; Humes 2023), noting variable screening, instrumentation and confounder control. He considers those works useful in showing that young-adult medians exceed 0 dB HL, but insufficiently robust to set a higher cohort-wide baseline than the 2017/2024 standard.

256. Mr Cox rejected the need for any baseline correction in his section of the joint report. He did so in reliance on three key papers. The first is 2017/2024 standard itself, which provides that, if there is a difference between the hearing of 18-year-olds and the thresholds set out in 2017/2024, the two values can be considered to be one and the same. The second is Kurakata et al., "Pure-tone air conduction thresholds of Japanese high-school students", 2010 ("the Kurakata 2010 study"). The conclusion from the Kurakata 2010 study was that the hearing threshold level at the age of 18 years, as adopted in ISO 7029:2000, serves as a good reference to illustrate the age-related decline of hearing sensitivity. The final paper is the Kurakata 2023 study, which concluded that its results and the 2017/2024 standard show a smaller threshold deviation (i.e. a lower threshold value) at high frequencies above 2 kHz compared to the 2000 edition.

257. In any event, Mr Cox disagreed with the Lutman 2024 paper's comment that the CLB guidelines specifically add suitable baseline corrections to convert the relative hearing threshold levels of ISO 7029:2000 to absolute hearing threshold levels. Mr Cox asserted that CLB used data from ISO 7029:1984, and ISO 7029:2000 does not set out a method of baseline adjustment.

The Defendant's Arguments

258. Mr Platt submits that all versions of ISO 7029 report HTLs relative to the median hearing threshold at age 18, not as absolute values. A defined baseline (representing the median HTLs for otologically normal 18-year-olds) must therefore be added to obtain absolute HTLs. Earlier iterations of the ISO acknowledged this concept, and the 2017/2024 standard likewise expresses HTLs relative to the 18-year median. The practical question is not whether a baseline is needed, but whether it is effectively 0 dB or a positive value at the test frequencies.

259. He contends that multiple papers demonstrate a clear, positive baseline at most frequencies; that the CLB 2000 values (derived from Lutman & Davis 1994) are well-supported; and 2017/2024 involved subtracting non-zero offsets corresponding to the 18-year median, which must be added back when reconstructing absolute thresholds. He relies in particular on Lutman & Davis (1994) which reported median HTLs for 218 screened, otologically normal British adults aged 18–30. He says that age within this band did not significantly influence thresholds; in other words, the fact that there are people older than 18 (i.e. 19 up to 30) does not significantly influence the result because there is no real decline in hearing for those aged 30 and below from age 18.

260. Table 6 showed medians (dB HL): 0.25 kHz 7.5; 0.5 kHz 5; 1 kHz 2; 2 kHz 3.5; 3 kHz 4; 4 kHz 6; 6 kHz 13; 8 kHz 7.5. CLB (2000) adopted these as baseline corrections, reducing 6 kHz by 6 dB to account for a TDH-39 earphone artefact, yielding: 0.25 kHz 7.5; 0.5 kHz 5; 1 kHz 2; 2 kHz 3.5; 3 kHz 4; 4 kHz 6; 6 kHz 7; 8 kHz 7.5.

261. He refers to several studies in support of his argument:

- Davis (1995) and UK National Study of Hearing (NSH). He says that the NSH provided a second British dataset of screened 18–30-year-olds (male medians, dB HL): 0.25 kHz 6; 0.5 kHz 3; 1 kHz 1; 2 kHz 2; 3 kHz 2; 4 kHz 4; 6 kHz 12; 8 kHz 5.5, with the 6 kHz value reflecting a 6 dB TDH-39P artefact (I return to the TDH-39P artefact below). Screening protocols for noise and ototoxic exposures were detailed and extensive.
- Smith et al. (1999) reported HTLs for 93 otologically normal British participants aged 18–25 under very strict screening. Averaging ears, median HTLs (dB HL) were approximately: 0.25 kHz 5.0; 0.5 kHz 2.7; 1 kHz 1.0; 2 kHz 2.6; 3 kHz 1.8; 4 kkHz 2.9; 6 kHz 4.0; 8 kHz 4.3. Discrepancies from Lutman & Davis (1994) were attributed to audiometric procedure, care of testing, and earphone differences; the large 6 kHz difference was consistent with TDH-39 vs TDH-50 effects.
- von Gablenz & Holube (2016) screened German males aged 18–19 showed median HTLs (dB HL) near: 0.25 kHz 0.8; 0.5 kHz 0.8; 1 kHz 0; 2 kHz 0;

3 kHz 1.7; 4 kHz 5; 6 kHz 5; 8 kHz 7.5—again indicating positive baselines, especially at higher frequencies.

- Zhang et al. (2022) screened males aged 15–24 reported medians (dB HL): 0.5 kHz 6; 1 kHz 6; 2 kHz 4; 3 kHz 5; 4 kHz 6; 6 kHz12, closely aligning with Lutman & Davis (1994) at key frequencies.
- Humes (2023) considered screened males aged 20–29, median HTLs were above 0 dB at all measured frequencies, with around 5 dB at 0.5, 3 and 4 kHz, and around 10 dB at 6 and 8 kHz.

262. Mr Platt also submits that working papers for the 2017/2024 standard indicate that, for each contributing study, the median 18-year HTL (the "offset") was estimated and subtracted prior to modelling; these offsets ranged roughly from −3 dB to +11.9 dB depending on frequency and study, and when averaged over 0.25–8 kHz fell around 1.4–4.5 dB. By arithmetic, those offsets must be added back to reconstruct absolute thresholds. Examples include datasets from von Gablenz & Holube (Germany), Davis (UK), Tsuiki (Japan), Engdahl (Norway), and Kurakata (Japan).

263. Mr Platt described Kurakata et al. (2010) as "a small study of 17 Japanese schoolboys aged 15–17" which has been cited for a 0 dB baseline argument. However, its median values were not 0 at all frequencies, the study rounded its figures to the nearest 5 (i.e. 0, 5, 10 etc. - so, e.g. 2.4 would be considered as 0), mean values were consistently above 0 at several frequencies, and the population is small and culturally distinct from the British largely male cohort before the Court. Moreover, when pooled with Kurakata (2011) in the 2017 standard working set, most back-projected offsets remained positive at multiple frequencies.

The Claimants' Arguments

264. Mr Steinberg advances a comprehensive challenge to the current conventions surrounding baseline corrections in the diagnosis and quantification of NIHL. He says that the practices embedded in CLB/LCB methodology lack evidential foundation, scientific coherence, or proper justification. He contends that these practices have become entrenched through repeated legal usage, rather than empirical validation. He says that reliance on the 1984/2000 standard as the age-related normative baseline results in systematic under-recognition of NIHL. The 1984 dataset predates modern screening and includes individuals whose hearing may have been degraded by undetected noise or ototoxic exposure. This "inflated" age-related expectation reduces the apparent NIHL component in any differential calculation, producing a structural bias against Claimants.

265. He argues that the 2017/2024 standard provides a more rigorous and scientifically defensible baseline: it is based on larger, more reliably screened, otologically normal populations; it reflects contemporary normative hearing thresholds; and it corrects several methodological shortcomings of earlier standards. Mr Steinberg contends the 2017/2024 standard should replace the 1984/200 standard for any scientifically valid baseline calculation.

266. He says that rigid correction factors, whether age-related or device-related, create misleading precision. Baseline determination must instead be anchored in the

Claimant's audiometric series, clinical context, and the overall consistency of test results. Automatic additions, without regard to individual variability, risk injustice and are inconsistent with normal ENT practice.

267. Further, he submits that using population averages to downplay individual NIHL findings risks treating a Claimant as a statistical abstraction rather than applying clinical judgment to individual evidence. He says that accurate baseline establishment is essential for both diagnosis and quantification. An inflated AAHL baseline may erase the evidential signifiers of NIHL. Mr Steinberg submits that proper baseline construction must be evidence-based; contemporaneous with modern audiological science; and sufficiently flexible to take account of human variation.

268. Mr Steinberg contests the value of the papers upon which Mr Platt bases his argument. In short, Mr Steinberg says:

- The dataset in Lutman & Davis (1994) amalgamates ages 18 to 30, thereby introducing age-related confounding. Further, the screening threshold of 97 dB(A) NIL permits inclusion of individuals with probable noise-induced impairment. The statistical reliance upon mean values compounds the methodological deficiencies. Accordingly, he submits, this study should not be regarded as a reliable basis for altering the ISO baseline.
- The Smith et al (1999) paper was presented as a replication of Lutman & Davis. However, it produced inconsistent results, with discrepancies of up to 9 dB at 6 kHz. Inadequate screening and age contamination, he says, renders its findings unreliable.
- The relevant subsample in von Gablenz & Holube (2016) comprises only three individuals aged 18-19. Such a sample cannot sustain any inference of population norms. It is submitted that this study should carry no weight in determining the baseline.
- The von Gablenz et al (2020) study employed an age band extending to 24 and includes testing in non-laboratory environments. These factors introduce uncontrolled variability and age-related effects. It is submitted that such methodological departures make this study unreliable.
- The study by Zhang et al (2022) had as its primary object to examine kurtosis in industrial settings, not to establish international normative baselines. Environmental confounders and inadequate screening undermine its applicability. It is submitted that this authority should not be adopted as a comparator for ISO purposes.
- The Defendant cite Humes (2023) to suggest that there are elevated thresholds among young adults. The Claimants submit that the cohort spans ages 20-29 and relies upon questionnaire-based screening, insufficient to exclude hazardous noise exposure. These limitations render the findings unsuitable for revising the ISO baseline.

269. The Claimants submit that the Defendant's reliance upon outdated, inadequately screened, and statistically flawed datasets is misplaced. Such authorities fail to isolate the reference age and introduce confounding variables that compromise their integrity. Conversely, ISO 7029 (2017) embodies a rigorous, multi-country,

and methodologically robust approach, rendering it the appropriate standard for judicial determination.

270. The Claimants rely upon the paper by Kurakata et al (2010), which examined adolescents aged 15 to 17 under stringent screening protocols. They argue that the findings disclose no material deviation from the 0 dB reference, thereby reinforcing the validity of ISO's baseline assumption.

271. Mr Steinberg says that the 2017/2024 standard, is the authoritative comparator. It aggregates extensive international data under stringent screening protocols and expressly contemplates minor deviations without mandating external offsets. This standard commands adherence in the absence of compelling evidence to the contrary.

Discussion

272. In my judgment, the Defendant has the better argument on the point of principle namely that some adjustment is necessary, but the Claimants, on their alternative case, are right as to the extent of the correction required.

273. There is no dispute that the values in ISO 7029 (2017) are expressed *relative* to baseline figures of the median hearing threshold of otologically normal individuals at age 18. They are relative figures, not absolute ones. An adjustment is required if, on proper analysis, the median hearing threshold level for 18-year-olds is higher than 0 dB.

274. However, in my view, Mr Steinberg is right in his criticisms of the papers relied upon by Mr Platt. In particular, it is clear that hearing loss is associated with increasing age, even amongst men in their 20s. To include in a cohort being studied men aged 19-24, or even more obviously aged 19-29 makes it impossible reliably to calculate the median hearing loss at age 18. von Gablenz & Holube is too small a study to carry any real weight. The findings in Zhang et al, such as they were, were incidental to the main focus of the work.

275. However, Mr Platt makes well-founded criticism of the Claimants' use of Kurakata et al which examined adolescents aged 15-17. It is possible to have a hearing loss at less than zero and so there can be no automatic read-across from a group aged 15-17 to men aged 18. Furthermore, this was a small study of culturally distinct young men and even there the median values were not zero at all frequencies.

276. The ISO youngest-adult deviation (≈2.4 dB across 1–8 kHz) supplies a modest allowance consistent with biological variability. Elevating the global figure materially beyond this level would risk obscuring genuine noise-related excess, especially at the higher frequencies commonly implicated in military NIHL.

277. In my judgment, a baseline correction is required in principle. I have held above that the 2017/2024 standard should be adopted as the reference standard for AAHL. In the generality, a cohort-wide allowance of 2.4 dB at each frequency 1–8 kHz should be adopted.

(iii) The Possible Effect of TDH39P Headphones

278. This apparently arcane issue is important because of the suggested effect of a particular type of headphone, the plastic TDH39P, (or its predecessor the metal TDH39) on the measurement of hearing loss at a particular frequency, namely 6 kHz. Prof. Lutman has long advocated applying an approximate 6 dB improvement to hearing thresholds measured at 6 kHz when TDH-39P supra-aural earphones had been used and calibrated on acoustic couplers.

The Competing Cases

279. The parties' competing cases on this issue can be summarised as follows.

280. The Claimants' position is that:

- There should be no automatic deduction of 6 dB when an HTL at 6 kHz is measured using TDH39P earphones.
- In those cases where the precise 6 kHz measurement could potentially make a difference to diagnoses of NIHL or the quantification of the hearing loss, the ENT expert should approach the measurement with caution and assess it in the context of its audiometric series.

281. The Defendant submits that:

- The audiometric artefact which exists at 6 kHz when TDH39P earphones are calibrated with a coupler (in accordance with ISO-389) is well established and supported overwhelmingly by available test studies. This appears to require an adjustment of about 6 dB to readings taken at 6 kHz.
- The position of Prof. Moore is frankly somewhat curious and his motivations for taking on this dispute are unclear. It may reflect his ideological inclination to try and maximise diagnosis and quantification of hearing loss claims.
- The only basis for his position appears to be (again) a study undertaken by himself- this time with Mr. Lowe. However, the approach taken in this study is entirely misconceived.
- In any event, the ultimate position of Prof. Moore appears to be that there is some unreliability and test variation with TDH-39 earphones calibrated in this way but that the only adjustment which he will now admit is between 1 and 4 dB.

The Competing Expert Opinion

282. As noted above, for many years Prof. Lutman has advocated applying an approximate 6 dB improvement to hearing thresholds measured at 6 kHz when TDH-39P supra-aural plastic earphones had been used and calibrated on acoustic couplers. The basis of his opinion was set out in a 1998 paper by him and Dr Qasem entitled "*A source of audiometric notches at 6 kHz. Advances in Noise Research vol. 1: Biological Effects of Noise*". Their conclusion was that it was necessary to subtract 6 dB from the measured audiometric reading at 6 kHz

where TDH-39P earphones have been used to account for what the authors called as a 'calibration artefact'.

283. The Qasem/Lutman approach was challenged in 2021 in a paper by Lowe and Moore, *Audiometric assessment of hearing loss sustained during military service*. Prof. Moore opposes a fixed correction or adjustment, noting inconsistencies across studies and comparative datasets, where introducing a 6-kHz correction had yielded anomalous patterns (for example, 6-kHz thresholds becoming better than 4 and 8 kHz). The argument was further developed the following year in a paper by Moore, Lowe and Cox, *Guidelines for Diagnosing and Quantifying Noise-Induced Hearing Loss.*

284. Before exploring the disagreement, I note the areas of agreement.

The Common Ground

285. TDH-39 is a type of earphone fitted to audiometers and used for pure-tone audiometric tests. According to Prof. Lutman, it is probably the most common type of earphone fitted to audiometers in the UK. When first developed in the first half of the 20th century, it had a metal diaphragm. However, a model with a plastic diaphragm was developed, referred to as TDH-39P, in the mid-1970s. TDH-39P have by now effectively replaced the older TDH-39 and have been used for the last 50 years.

286. It was agreed by Professors Moore and Lutman in the generic joint statement, that there will be variations among and between TDH39 earphones, which mean that the ultimate calibration at 6 kHz will vary as between batches and samples within those batches (so that there will not be a consistent impact on the audiometry).

287. The literature on this issue exhibits inconsistencies that are probably explained mainly by variations among the examples of TDH-39 earphones used in the various studies. Minor differences in the resonance frequency of the earphone when placed on the acoustic coupler used for calibration, which is around 6 kHz, can have a substantial effect on its ultimate calibration at 6 kHz.

288. Prof. Lutman confirmed that variability in his oral evidence (day 18 166.1):

> *Q. You seem to be saying that the inconsistencies in the literature are explained by variations among the TDH39 headphones which were used. Am I reading that correctly?*
> *A. Yes.*
> *Q. Which must mean, therefore, mustn't it, that the characteristics of headphones can vary from one sample to the next?*
> *A. That's my interpretation.*
> *Q. Okay. All right. That is especially true, it seems, of the TDH39 family and especially true of 6 kilohertz?*
> *A. Yes.*

The Strength of the Lutman and Qasem Paper

289. Mr Platt says that the evidence in support of existence of the "calibration effect" is overwhelming. He refers to the following five papers.

290. First, a paper by DW Robinson paper in 1988 *Threshold of hearing as a function of age and sex for the typical unscreened population* in the British Journal of Audiology, which Mr Platt says showed that, in population studies of young participants, where TDH-39 earphones were used, mean measured HTLs at 6 kHz were approximately 5 dB higher than at other frequencies. However, having considered the paper, I have been unable to confirm that TDH-39 earphones were used and certainly I have found no suggestion that the plastic version, the TDH-39P, was used.

291. The second referred to is one by Canning in 1991 "*An initial investigation into the equivalence of the metal and plastic-cased TDH39 earphones"*, which suggests that a correction of 7.3 dB is required at 6 kHz for TDH-39P. Third, is a paper by Sherwood in 1995 that suggests that a correction of 5.7 dB is required at 6 kHz for TDH-39P earphones.

292. However, as Prof. Lutman accepted in cross-examination, the essential conclusion from the Canning and Sherwood papers was that there was variability between earphones of the one type. The following extract from Prof. Lutman's cross-examination makes the point:

> *Q. What it means, I will suggest, is that both Sherwood and Canning have demonstrated variability between headphones of the same type and took the view that the batch where they came from was relevant?*
> *A. Yes. They have shown a variation amongst earphones.*
> *Q. Which they explain potentially on the basis of the batch from which they came?*
> *A. That's the suggestion they make, yes.*

293. Fourth, Mr Platt relies on a paper by Poulsen in 2010 in which the author says the following:

> It is seen that apart from at 6000 Hz there is a good agreement between the DD 45 and TDH 39. It is well known and often discussed that the calibration value (RETSPL) for TDH 39 may be incorrect (Robinson et al, 1981; Fearn & Hanson, 1983; Lawton, 2005). Experience has shown that audiometry on normal-hearing persons often shows a probably fake hearing loss of about 5 dB at 6000 Hz if a TDH 39 earphone has been used for the audiometry.

294. However, it is right to observe that the subject matter of Poulsen's study was the DD45 earphone, not the TDH39 or TDH39P. He was not confirming the inaccuracy of the latter at 6 kHz but assessing the suitability of the former as an alternative.

295. Finally, I turn to the Lutman and Qasem paper itself. That was, as Prof. Lutman confirmed in evidence, part of Mr Qasem's Masters dissertation. It was not a peer reviewed study. More importantly it was based on consideration of only one pair

of TDH39P earphones and one pair of TDH39 earphones. The earphones were some years old. Given the possibility of variation between earphones, this provides a fragile basis for drawing any conclusions of general application.

296. Furthermore, this paper suggested that both the plastic and the metal TDH39 earphones gave incorrect results at 6 kHz when calibrated using an acoustic coupler. The mean thresholds for both were about 6 dB higher than they should have been. That is fundamentally different from Canning (1991) and Sherwood et al (1995) which showed a significant difference between the thresholds measured by the metal and plastic sets of TDH39 earphones. The paper acknowledged the issue, but made no attempt to resolve it: "*The reasons for this apparent contradiction have yet to be resolved*."

297. Interestingly, Prof. Lutman told me that "*the TDH39 metal earphone that Qasem used was actually one of the ones which was used by Sherwood*". That being so, it is surprising that in Sherwood's study the plastic and metal versions performed very differently but in the Qasem/Lutman study they were very similar. Prof. Lutman said he had

> looked carefully through the Sherwood study to try and identify why there was an apparent difference between their results and Qasem's but I couldn't find it. It is puzzling.

298. The potential consequences of applying the TDH-39 deduction were illustrated in the course of Mr Green's oral evidence in two ways. First, when considering Mr Lambie's audiograms, Mr Green agreed that the 6 dB deduction resulted in his 2024 audiogram showing an improvement in his left ear that was outside the 10 dB audiometric margin of error. Second, Mr Green agreed that if the audiogram did not satisfy the CLB criteria for a notch by 1 dB but only as a result of the 6 dB deduction, the criteria for a positive diagnosis would not be met.

299. I note further that, as Mr Steinberg submits, an automatic 6 kHz correction is not recommended by the BSA and plays no part in the real world of audiology in the NHS or elsewhere. It is simply a medico-legal convention deployed in the UK. In my judgment it is a convention built on very shallow foundations.

The Moore, Lowe and Cox Paper

300. The paper by Moore, Lowe and Cox is also open to challenge. As Mr Platt correctly contends, the authors did not test the same subjects with different types of earphones. Rather, they reviewed the test results of two different groups of subjects (one numbering 58, one numbering 80) who had undergone audiograms with different types of earphones. Prof. Lutman argued that "*comparison between samples is less powerful than comparison of measurements using the two types of earphones on the same ear, as performed by Lutman and Qasem*". I agree.

301. Much of Mr Platt's attack on the Moore paper involves a response to the attack on the Lutman and Qasem paper which I have addressed above. I accept his submission that the Moore paper does not justify a conclusion that no adjustment is appropriate at 6 kHz.

302. Mr Platt is also correct to point out that Prof. Moore's position altered during the course of the evidence, from opposition to any adjustment at 6 kHz to acceptance that some adjustment was appropriate. Prof. Moore said the following in cross-examination:

> *A: That is a question of the inherent variability. It doesn't indicate the need for a systematic correction, it just means that it is better not to use TDH39 headphones because of the high inherent variability which can, by chance, lead to notches in the audiogram, even without the need for a systematic correction... But I think the study of David Lowe and myself suggests that, if a correction is needed, then 6 dB is certainly too big, and possibly -- I allow the possibility that a smaller correction is needed, but just what it is is not clear.*
> *Q. Well, are you going to give us any sort of figure that you would accept?*
> *A. It could be anything in the range 1 to 4 dB, I would guess.*
> *Q. Okay. So we agree in the principle of an artifact, we just don't agree the extent of the artifact as a matter of --*
> *A. I am saying there could be an artifact and, if there is an artifact, it is probably in the range 1 to 4 dB. But the data of Lowe and Moore don't provide any support for a correction of 6 dB.*

303. In substance, Mr Steinberg accepts that position.

304. It is not possible on the evidence I have seen to say what reduction should be made to the measurement at 6 kHz where an adjustment is thought to be appropriate. It has to be a matter for the ENT expert viewing the whole audiometric series.

305. Against that background I conclude as follows on this issue:

(i) TDH39P earphones are liable to produce variable results at the 6 kHz frequency.
(ii) However, there should be no automatic deduction of 6 dB when an HTL at 6 kHz is measured using TDH39P earphones.
(iii) Whenever the precise 6 kHz measurement could make a difference to the diagnosis or quantification of NIHL, the ENT expert should approach the measurement with caution and assess it in the context of the audiometric series of which it forms part.
(iv) They should make an adjustment if they deem it necessary (to the extent that they deem appropriate) to ensure it is consistent with the rest of the audiometric series.

Chapter 8 -The Appropriate Diagnostic Method

306. This chapter addresses the question as to how military NIHL should be *diagnosed*. The related issue of how it should be *quantified* is dealt with in the following chapter.

307. In this chapter I address the different approaches to the diagnosis of NIHL in military cases advocated by Prof. Brian Moore and Prof. Mark Lutman as considered and deployed by the ENT experts, Mr Cox and Mr Green. This issue is critical to many of the cases in this cohort and it is convenient first to describe the competing methods and then set out the extent of the agreement between the two, before turning to discuss the conclusions to be drawn on the matters in dispute.

308. Diagnosis of NIHL in an individual case is a matter for the clinical judgement of the medical expert, guided by a diagnostic audiometric method. There are four diagnostic methods to be considered, known respectively as CLB, M-NIHL, rM-NIHL and MLP(18). That any of these tools or methods provide only guidance to clinicians was ultimately common ground. CLB was, from the beginning, expressed as "guidelines"; in his oral evidence (although not on the face of the papers) Prof. Moore, the principal author of the other three, agreed that his methods too could only be regarded as guidelines and were subject to clinical judgment. There may well be cases for which none of the methods is completely appropriate; clinicians and experts cannot entirely substitute the application of their preferred diagnostic tool for individual clinical judgement.

The Competing Contentions

309. The Claimants invites the Court to make the following findings on diagnostic methods:

- Military NIHL can present without a CLB notch/bulge and the absence of a notch does not exclude NIHL.
- Military noise commonly affects hearing at 8 kHz and this can erase or disguise a notch or bulge.
- Military impulse noise produces different cochlear injury and tends to produce a different and more variable audiometric pattern than steady state or typical industrial noise.
- CLB is not generally suitable for military cases. CLB was not designed for impulsive military noise, while the rM-NIHL method adapts the audiometric criteria to this specific context.
- Applying equal assumptions, the specificity of CLB and rM-NIHL is similar, but rM-NIHL is more sensitive to true military NIHL and therefore superior as a diagnostic tool in these cases.
- Medical experts should, nonetheless, be free to apply whichever diagnostic criteria bests assists in reaching an overall conclusion based on the totality of the evidence.

310. The Defendant invites the Court to reach the following conclusions:

- CLB should be preferred as the audiometric method forming part of the medical expert's overall diagnostic enquiry in military NIHL cases. It is more widely applicable (to men and women, with no age limit), more flexible (it can be used with different AAHL data sets, with or without a baseline correction etc.), more able to be tailored to an individual (because it does not simply contrast all Claimants with the 50th centile/median), more developed with informative "Modifying Factors", and less prone to false positives than the various methods of Prof. Moore. It works well as a diagnostic method in the cases before the Court. Even the Claimants' experts, Mr Zeitoun and Mr Cox, use it. Concerns about its general suitability in military cases are misplaced and any particular problems (such as the 8 kHz issue) can be remediated within its own terms.
- Little time need be spent on Prof. Moore's M-NIHL method. It would be illogical to prefer this, since it has been specifically revised and thus superseded by rM- NIHL, which identified major shortcomings in it and does not recommend using M-NIHL as a fallback or cross-check. It has notably poor specificity.
- rM-NIHL is a better method than M-NIHL but still should not be preferred to CLB. It is more vulnerable than CLB to false positives (according to both Prof. Moore and Prof. Lutman) and is rigidly tied to comparing all Claimants to the median. Its requirement R2b simply represents hearing that is somewhat below the median, hence it can take no account of idiopathic loss or variation and/or the possibility that a Claimant might always have had below-median hearing. It is restricted in its use to a certain age group of men. There are difficulties with its development, which was based on a group of Claimants (who were all assumed to have NIHL, irrespective of the outcome of their claims or the opinion of medical experts) and a control group of German nationals that was not perfectly matched.
- MLP(18) should be rejected because its outputs are opaque – they are a 'black box' which cannot be interrogated or challenged by experts, lawyers or the Court. It is restricted in its use to men of a certain age bracket. It is an inflexible static model that depends on the Court accepting Prof. Moore's other views on AAHL data set, baseline correction, TDH39P headphones etc. Prof, Moore has significantly 'moved the goalposts' about the meaning of its output values during the trial. It is, per Prof. Lutman, "*poorly conceived and fundamentally flawed*" because its primary accomplishment is that it simply discriminates Claimants from a German–control group without a history of noise exposure – it is not a differential diagnostic test. It demonstrates very high false positive rates, being driven by the recognition of poor hearing in general.

The Competing Methods

311. The first diagnostic method in time was that set out in the paper of Coles, Lutman and Buffin (CLB) published in Clin Otolaryngol 2000, 25, 264-273 in April 2000 and entitled "*Guidelines on the diagnosis of noise induced hearing loss for medico legal purposes*". As explained in the abstract to that paper:

these guidelines aim to assist in the diagnosis of noise induced hearing loss (NIHL) in medical legal settings.... It is argued that the amount of NHIL needed to qualify for that diagnosis is that which is reliably measurable and identifiable on the audiogram. The three main requirements for the diagnosis of NHIL are defined: R1, high frequency hearing impairment; R2 potentially hazardous amounts of noise exposure; R3 identifiable high frequency audiometric notch or bulge. Four modifying factors also need consideration: MF1, the clinical picture; MF2 compatibility with age and noise exposure; MF3, Robinson's criteria for other causation; MF4, complications such as a symmetry, mixed disorder and conductive hearing impairment.

312. The paper expressly defined its scope. Paragraph 2 reads as follows:

> 2.1 For the most part, the guidelines refer to uncomplicated cases of NIHL: that is cases of "typical" NIHL together with presumed "normal" AAHL (age associated hearing loss).
>
> 2.2 In the present context, "typical" NIHL" refers to the form of hearing impairment that gradually accrues in a proportion of those who have repeated exposures to hazardous levels of one or more of the common type of broadband sounds. Sounds not fitting this description include those predominantly of tonal nature or of low frequency or very high frequency spectrum. Examples of such unusual spectra would be where the sound level is greater than 10 dB in the 0.25, 0.5 or 8kHz octave bands.
>
> 2.3 "Normal" AAHL here implies consistency with the range of age associated hearing data in ISO 7029 (1984) for the appropriate age and sex, and also having the most common audiometric configuration of a HL in which the hearing loss increases progressively with test frequency and with age, the progression having an accelerating character.

313. Requirement R1 of CLB is a requirement for a high frequency hearing impairment. It requires that one (or more) measured HTL at 3, 4 or 6 kHz should be at least 10 dB greater than the measured HTL at 1 or 2 kHz. Requirement R2 relates to a required 'dose' of noise exposure. However, it is common ground that this is not required in military cases. Requirement R3 is an 'audiometric configuration' that is consistent with damage to hearing caused by noise at 3 and/or 4 and/or 6 kHz. It can be either a 'notch' or a 'bulge' (in either case of 10+ dB).

314. 'Notch' is defined at paragraph 7.5 of CLB. It is a dip in the measured HTL at 3 and/or 4 and/or 6 kHz that is at least 10 dB greater than at 1 or 2 kHz and 6 or 8 kHz. 'Bulge' is defined at 7.6 of CLB as a difference of at least 10 dB between the measured HTLs at 3 and/or 4 and/or 6 kHz relative to an estimate of AAHL for that individual. Calculating a bulge, which is described in Appendix B of CLB involves (in simplified terms) looking at the 'anchor points', namely measured HTLs at 1 and 8 kHz, choosing an appropriate AAHL dataset for the individual based on the anchor points, and then constructing AAHL values for the individual, against which the measured HTLs can be compared. The availability of a 'bulge', in addition to a 'notch', as a diagnostic marker under R3 CLB takes

account of the situation where HTLs at higher frequencies might deteriorate because of age (or indeed further NIHL) such that a notch that was present becomes no longer visible. The point is explained in CLB itself at paragraph 7.2:

> In a considerable proportion of NIHL cases, especially after the age of about 50 years, the characteristic high- frequency notch is missing. This is usually due to the additional presence of high-frequency hearing impairment of other causation, either pre-existing or developing concurrently or subsequently, such as associated with ageing. Typically that has the effect of converting a noise-induced audiometric notch into a bulge.

315. A 2016 paper by Lutman, Coles and Buffin ("LCB"), a paper directed primarily to quantification rather than diagnosis, makes a number of specific modifications to the CLB diagnostic method with respect of the bulge calculation under requirement R3; it was modified by LCB to require (i) the use of 1 and 8 kHz only as the anchor points, (ii) the use of AAHL statistics, matching as closely as possible to the individual Claimant's actual age and (iii) logarithmic, rather than linear, interpolation of "misfit values" (i.e. the values to be applied to missing data points).

316. The second method, M-NIHL, was set out in an article by Prof. Moore in the Journal of the Acoustical Society of America ("the JASA") published in August 2020. The abstract to that article sets out its objectives:

> The diagnosis and quantification of …NIHL in a medico legal context are usually based on the pattern of hearing loss that is typically associated with long term exposure to steady broadband noises, such as occur in noisy factories. Evidence is reviewed showing that this pattern is not typical for hearing loss produced by intense impulsive sounds of the type that military personnel are exposed to. The audiometric characteristics of noise exposed military personnel are reviewed. A set of audiograms from a sample of 58 hearing impaired noise exposed military veterans was analysed and used to develop methods for the diagnosis and quantification of military NIHL three requirements are specified for diagnosing military NIHL.

317. It is apparent that the M-NIHL method was developed by Prof. Moore specifically for military cases. It requires that other plausible causes of hearing loss had been excluded through medical history (e.g., conductive loss, infections, family history, ototoxic drugs, substantial non-military noise) and, where available, that baseline audiograms at entry to service had shown average HTLs of less than or equal to (≤) 20 dB HL without large across-ear asymmetry (≥10 dB). The diagnostic decision was to be based on criteria R1 and R2a or R2b.

318. Those three requirements were as follows:

> R1 A single value of the HTL at 3, 4, 6, or 8 kHz is at least 10 dB higher than the HTL at 1 or 2 kHz. This is similar to requirements R1 of the CLB method except that the frequencies "3, 4 or 6 kHz" have been replaced by "3,4,6 or 8 kHz" to allow for the findings summarised above, that military noise exposure typically produces the greatest hearing losses at 4, 6 and 8 kHz but that it sometimes produces the greatest loss at 3kHz.

> R2a The difference between HTLs at 8 and 6 kHz is at least 5 dB smaller than would be expected from age alone or the difference between HTLs at 8 and 4 kHz or between 8 and 3 kHz is at least 10 dB smaller than would be expected from age alone based on ISO 7029 (2017) …
>
> If requirements R1 and R2a are met, this provides reasonably strong evidence for M-NIHL. If requirement R2a is not met, this does not imply the absence of M-NIHL, since military noise exposure can have a substantial effect, and sometimes its maximal effect, on the HTL at 8 kHz. If requirement R2a is not met, then the diagnosis of M-NIHL can be made if R1 is met, there is no reason to suspect a hearing loss that is not age-related or noise related, and the following requirement is met: 2(b) HTL at any one of 4, 6 or 8 kHz is at least 20 dB higher than the median HTL for each frequency expected for that age, based on ISO 7029 (2017).

319. It is to be noted that R2 of M-NIHL involves comparison with what would be expected as a result of age alone. By contrast, the bulge calculation under R3 of CLB amounts to the comparison of measured HTLs with expected AAHL HTLs.

320. The third method is a modification of the second. It is based on a paper by Prof. Moore and others, published in "*Trends in Hearing*" volume 26 in September 2022, and entitled "*Modification of a Method for Diagnosing Noise Induced Hearing Loss Sustained During Military Service*". The abstract reads as follows:

> Moore (2020) proposed a method for diagnosing …NIHL sustained during military service, based on an analysis of the shapes of the audiograms of military personnel. The method, denoted M-NIHL, was estimated to have high sensitivity but low to moderate specificity. Here a revised version of the method, denoted rM-NIHL, was developed that gave a better balance between sensitivity and specificity. A database of 285 audiograms of military noise-exposed men was created by merging two previously used databases with a new database, randomly shuffling, and then splitting into two, one for development of the revised method and one for evaluation. Two comparable databases of audiograms of 185 non-exposed man were also created, again one for development and one for evaluation. Based on the evaluation databases, the rM-NIHL method has slightly lower sensitivity than the M-NIHL method, but the specificity is markedly higher. The two methods have similar overall diagnostic performance. If an individual is classified as having NHIL based on a positive diagnosis either ear, the rM-NIHL method has a sensitivity of 0 .98 and a specificity of 0.63. Based on a positive diagnosis for both ears, the rM-NIHL method has a sensitivity of 0 .76 and a specificity of 0 .95

321. The paper notes at page 1 that the

> ideal balance between sensitivity and specificity depends on the purpose of making a diagnosis of NIHL. If the diagnosis is made to support a claim for compensation for NIHL then to be fair to the individual it is important that a reasonably high proportion of individuals who do have NIHL receive a positive diagnosis. This must be balanced against the need to avoid payment of compensation to individuals who do not have NIHL. In a medicolegal

> context, the criterion is usually the "balance of probabilities" ie for a positive diagnosis to be made, it should be more likely than not that the individual has NIHL. However, this depends not just on the audiogram, but on other factors as discussed below… Our goal was to develop a method with an appropriate balance of probabilities defined as specificity greater than 0.6 based on a positive diagnosis for either ear with sensitivity greater than 0.7 based on a positive diagnosis for both ears

322. The paper identified a number of problems with the M-NIHL method (see page 2). It said that applying that method "*showed that false positives ... often occurred because the difference in HTLs at 6 and 8 kHz just met the minimum 5 dB criterion set out in the M-NIHL method*." The R2a requirement of the M-NIHL method was modified by creating a magnitude value corresponding to the size of the notch or bulge and then determining what magnitude value gave a good balance between sensitivity and specificity, a quantity described as "*Mag(Notch*"). R2b of M-NIHL "*was modified to be based on the average HTL across 4, 6 and 8 kHz.*"

323. Thus, the rM-NIHL retained the military focus while refining statistics and screening criteria. It continued to assume thorough exclusion of alternative causes and emphasised careful handling of ear asymmetry by using entry-service audiograms where available. rM-NIHL allows percentile-based adjustments and explicitly draws on ISO 7029 parameters (2017, corrected 2024) to model age-expected medians and spreads. Sensitivity and specificity were evaluated against screened control datasets. When properly applied, it was anticipated that the method would reduce false positives relative to the original formulation, without sacrificing sensitivity in veterans whose audiograms had shown high-frequency losses typical of exposure to intense or impulsive sound. For quantification, rM-NIHL had produced estimates of NIHL magnitude as the gap between measured thresholds and age-expected values at selected frequencies, with guidance encouraging consistency across cases while permitting expert judgement in percentile selection where audiometric evidence had warranted tailoring.

324. The fourth method was MLP (18), a product of Prof. Moore and Josef Schlittenlacher. It was first set out in a paper published in Trends in Hearing in June 2023. The abstract for the paper reads as follows:

> The diagnosis of …NIHL is based on three requirements: a history of exposure to noise with the potential to cause hearing loss; The absence of known causes of hearing loss other than noise exposure; And the presence of certain features in the audiogram. All current methods for diagnosing NIHL have involved examination of the typical features of the audiogram of noise exposed individuals and the formulation of quantitative rules for the identification of those features. This article describes an alternative approach based on the use of multi-layer perceptrons (MLPs). The approach was applied to databases containing the ages and audiograms of individuals claiming compensation for NIHL sustained during military service... who were assumed mostly to have M-NIHL, and control databases with no known exposure to intense sound. The MLPs were trained so as to classify individuals as belonging to the exposed or control group based on their audiograms and ages, thereby automatically identifying the features of

the audiogram that provided optimal classification. Two databases (noise exposed and non-exposed) were used for training and validation of the MLP's and two independent databases were used for evaluation and further analysis. The best performing MLP was trained to identify whether or not an individual had M-NIHL based on age and the audiogram for both ears. This achieved a sensitivity of 0.986 and a specificity of 0.902, giving an overall accuracy markedly higher than for previous methods.

325. The two databases used to create MLP(18) were referred to as MilDB1 and ContDB1. The two used to test it were referred to as MilDB2 and ContDB2. MilDB1 and MilDB2 were composed of individuals who had noise exposure in the British military and ContDB1 and ContDB2 comprised individuals from a German population not known to have had exposure to intense sounds.

326. The paper acknowledged three limitations to the study it reports. First, the databases used for training, validation and testing of the MLPs were restricted to those claiming compensation for M-NIHL. It was acknowledged that that "*increased the likelihood of them having M-NIHL making them suitable for estimating the sensitivity of the MLP methods but with the risk that the hearing loss was exaggerated*". Second, "*the noise exposed and control samples were not matched in terms of alcohol consumption, smoking, socioeconomic status, or educational level, all of which are weakly associated with HTLs*". Third, the databases used for training, validation and testing of the MLPs "were *probably less highly screened than those in (the control groups) in terms of exposure to noise outside of military service*".

327. For three of the diagnostic methods, the CLB, M-NIHL, and rM-NIHL methods, the authors selected criteria intended to give what they regarded as a reasonable balance between sensitivity and specificity. The criteria for the MLP(18) method were not set explicitly, but the training used to develop the MLP(18) method was designed also to lead to a reasonable balance between sensitivity and specificity.

The Reports of Lutman and Moore: Areas of Agreement

328. As set out in their joint report dated 11 February 2024, Professors Moore and Lutman agree that the task of the medical examiner faced with a Claimant alleging NIHL is to determine whether the hearing of that individual is worse than it would have been if the individual had not been exposed to noise. That involves determining whether there is NIHL based on the noise-exposure history, the audiogram, and the age and the medical history of the individual. They agreed that their diagnostic methods are designed to aid the medical examiner in that task.

329. They also agree that:

(i) The CLB, M-NIHL, and rM-NIHL methods require there to be greater hearing loss at a frequency above 2 kHz than at either 1 or 2 kHz. The formulations for this requirement are similar but not identical. These three methods also include a measure of a notch or bulge in the audiogram, although again they are formulated somewhat differently. Importantly, the notch/bulge is a necessary condition (requirement) for the CLB methods but is only a sufficient (not necessary) condition for the M-NIHL and rM-NIHL methods. The M-NIHL and rM-NIHL methods include an alternative sufficient condition based on the extent of hearing loss at 4, 6 and 8 kHz relative to the hearing loss expected for men of the same age.

(ii) The CLB method includes guidance on how to deal with asymmetric cases, where a diagnostic indication arises on one ear but not the other. The M-NIHL and rM-NIHL methods treat each ear separately. The authors of those methods suggest that a positive diagnosis for one ear is sufficient for an individual to be diagnosed with M-NIHL. The MLP(18) method makes a diagnosis for the individual rather than for each ear separately.

(iii) The CLB method includes guidance on how to deal with cases where there is a component of conductive hearing loss. There is also guidance for dealing with non-standard cases in terms of the Modifying Factors MF1-MF4, recognising the heterogeneity of clinical case material. The M-NIHL guidelines do not include explicit guidance on those matters, leaving them to the judgement of the medical examiner.

(iv) The CLB method includes a requirement for noise exposure amounting to a Noise Immission Level (NIL) of at least 100 dB(A) in most cases, although the requirement is lowered to 90 dB(A) where there is particularly strong audiometric indication of NIHL. No guidance is given for impulsive noise. The M-NIHL guidance is to the effect that there must be: "*evidence of exposure to noise with sufficient intensity and duration to have the potential for producing NIHL. This is usually the case for former military personnel when they have seen active service and have not always worn hearing protection, especially when the individual reports experiencing temporary hearing loss and/or tinnitus during service*".

(v) NIL is not a suitable metric for impulsive noise such as produced by rifles or guns. Firing 100 or more rounds from a rifle without hearing protection produces hearing loss in a substantial proportion of individuals, so the "limiting" allowed exposure should be less than 100 rounds. For more sensitive individuals, even a single round may lead to hearing loss. A small number of rounds from artillery guns would also pose a hazard to hearing. A single explosion can cause material hearing damage.

(vi) The MLP(18) method does not have predefined requirements in terms of audiometric configuration. Rather the method was trained to use whatever features of the audiogram best distinguish those who are likely to have M-NIHL from those who are unlikely to have M-NIHL. The MLP(18) method gives a diagnosis based on the individual, rather than on each ear separately.

(vii) The MLP(18) method was trained using databases of noise-exposed and non-exposed men aged up to 60 years. As with all deep-learning methods, the MLP(18) method is only valid for cases that fall within the range of values it was trained on. Therefore, the MLP(18) method is applicable to men up to 60 years old. While the paper describing the MLP(18) method did not state explicitly that the method is applicable only to men aged 60 years old or less, that was the intention.

(viii) The MLP(18) method was developed based on data in the literature, and those data were largely, but not exclusively, concerned with men aged 60 years or less. The rM-NIHL method was developed based on the audiograms of noise-exposed and non-exposed individuals who were all men aged 60 years or less. Therefore, these methods should be used with caution for women or for men aged over 60 years. The CLB method does not include restrictions with regard to age or sex. However, Prof. Moore and Lutman are not aware of any published evaluations of the sensitivity and specificity of the M-NIHL, rM-NIHL, and CLB methods restricted to men aged over 60 years or restricted to women.

(ix) The audiometric indicators of NIHL used in the CLB, M-NIHL and rM-NIHL methods also occur for people not exposed to noise, which places an upper limit on the specificity that can be achieved using these guidelines, as such cases would constitute false positives.

Lutman and Moore - Areas of Disagreement

330. Their joint report also sets out the areas of disagreement between Prof. Lutman and Moore.

331. Prof. Lutman continued to support the CLB guidelines, which he said could be adjusted for age and the overall audiogram shape and had relied on identifying a notch or bulge centred near 3–4–6 kHz. He had contended that the M-NIHL approach had risked misattributing non-noise-related losses to NIHL, particularly in older individuals, and that its validation datasets had been vulnerable to selection biases.

332. Prof. Moore defended the M-NIHL and revised M-NIHL (rM-NIHL) methods, stating that, when properly screened for other pathologies and non-military exposures, those methods had demonstrated high sensitivity and acceptable specificity. He had criticised CLB for reduced sensitivity at older ages, where age-related elevation at 6 and 8 kHz had tended to mask or erase a classic 4-kHz notch that might have been present earlier.

The Evidence of the ENT Experts

333. The ENT experts were largely in agreement about the differences between impulsive and steady-state noise. In their joint report, they agreed that the damage to the ear from exposure to intense impulsive sound is not the same as from chronic broadband steady-state noise (with no impulsive exposure) and the audiometric pattern of hearing loss can be different. Even if there was noise exposure at similar sound pressure levels, the noise with substantial impulse components would be more hazardous than the noise without substantial impulse components. The reason for that is that, in response to impulsive noise, there is latency in the acoustic reflex (the muscles in the middle ear contracting to help protect the inner ear from damage by reducing the transmission of sound). The acoustic reflex is primarily triggered by low-frequency broadband sound, rather than by pure tones greater than 2kHz. As a result, exposure to intense impulsive sound is associated with a material risk of damage to the auditory system which can cause hearing loss symptoms, tinnitus, and hyperacusis. They noted that intense sounds with unusual frequency spectra are also seen in industrial noise exposure.

334. Mr Cox and Mr Green differed as to the ramification of the differences between these two types of noise on the choice of diagnostic guidelines. For Mr Cox, the resultant differing audiometric patterns militates against the CLB method.

Conversely, Mr Green maintained in his oral evidence that the CLB method is still suitable because the frequencies affected that are the most sensitive to noise (3, 4, and 6 kHz) remain similar, even if the higher frequencies are affected slightly more.

335. As noted above, in the Judicial Primer, the ENT experts stated that there are pathological differences in the pattern of damage caused by exposure to repetitive steady-state broadband noise, and the damage caused by impulsive noise and acoustic trauma. There was some debate as to whether acoustic trauma was distinct from impulsive noise (as well as steady-state noise). In his oral evidence Mr Green said that, in his view, there were three separate categories (with acoustic trauma characterised by a sudden loss of hearing) although the categories probably existed on a spectrum. Mr Cox addressed acoustic trauma in some detail in his own section of the joint report as a further reason for rejecting the CLB method. However, in cross-examination, he accepted that acoustic trauma is a niche issue which is not particularly common among military personnel, and therefore should not be used to construct a method for diagnosing progressive hearing loss.

336. As to the choice of diagnostic method, the ENT experts adopted positions similar to Prof. Moore and Lutman. Mr Cox generally preferred the Moore methods, although he allowed for an exceptional use of a modified CLB method. In his section of the joint statement, Mr Cox echoed the main criticism of the CLB method, namely that it requires a hearing loss centred at 4 kHz and adjacent frequencies which is often absent in military cases because of how military noise exposure often affects hearing thresholds at both low and high frequencies. Mr Cox attributes the different pattern of hearing loss in military cases to the different nature of military exposure. In oral evidence, Mr Cox emphasised that, although CLB can diagnose hearing loss centred at 6 kHz, it can only do so only where 6 kHz has been affected in isolation from 8 kHz (for example, the 8 kHz threshold would need to be 10 dB better than at 6 kHz to be deemed a 'notch') which is not normally the audiometric pattern in military cases. In response to the Defendant's suggestion based on LCB of replacing the 8 kHz threshold level with the expected age-associated hearing threshold level, Mr Cox was clear that this suggestion was only applicable to quantification rather than diagnosis.

337. Mr Cox, nonetheless, did accept two main propositions in cross-examination. Firstly, low-frequency hearing loss is problematic for the Moore methods as well as the CLB method. Secondly, under the rM-NIHL method, it is conceivable that an individual with poor hearing prior to enlistment (but just about good enough to be accepted onto military service) would still receive a positive diagnosis, although Mr Cox stressed that the medical assessment as part of the rM-NIHL method addressed this possibility.

338. In relation to his proposed exceptional use of a modified CLB method, Mr Cox explained in his section of the joint report that there may be a small minority of military personnel whose audiograms do not meet the Moore guidelines but do display the characteristics associated with the CLB guidelines. In those cases, assessment using a modified CLB approach might assist in establishing causation when used alongside assessments using the guidelines specifically designed for military use. In oral evidence, Mr Cox clarified that he does this where the

individual was "just a small fail" under the Moore methods, and the individual's clinical picture and history of noise exposure and symptoms (such as temporary tinnitus) do not point to any other cause.

339. Mr Green favoured the CLB guidelines. In his section of the joint report, his central issue with the Moore methods was their false positive rates, which he described as unacceptably high. He also highlighted that the CLB method remains in widespread use within the UK medical expert community. In oral evidence, he also pointed out that none of the guidelines were used in clinical practice, but only in medico-legal practice.

340. In cross-examination, Mr Green broadly accepted three main propositions. First, the scope of the CLB guidelines was limited to broadband industrial noise. Second, caution was required with the 1 kHz anchor point, which could be affected by intense low frequency exposure such as while travelling in military aircraft. However, Mr Green, citing the example of Mr Lambie, drew attention to the fact that the hearing loss at 1 kHz is significantly less than at the higher frequencies. Consistent with Mr Cox's evidence, he said that none of the guidelines covered exposure to low-frequency noises in any event. Thirdly, Mr Green recognised that the effect of military noise exposure on the 8 kHz anchor point means that a notch on the audiogram can often be lost. Nevertheless, he maintained that bulges can still remain if there is high hearing loss at 8 kHz, including even if the 8 kHz loss is slightly worse than at 4 and 6 kHz.

341. The problem of 'disappearing' notches or bulges was put to Mr Green. This refers to cases where there may have been noise-induced hearing loss earlier that manifested itself in a notch or bulge, but that notch or bulge has later 'disappeared' as a result of ageing and/or further noise damage at the 8 kHz anchor point. In such cases, Mr Green indicated that he would rely on the earlier audiogram showing a notch or bulge. If no earlier audiogram was available (which had never happened in a military case in his experience), then it would be very difficult to diagnose military noise-induced hearing loss as opposed to simply age-associated hearing loss. In any event, Mr Green made the observation that the problem of 'disappearing' notches or bulges exists in industrial cases as well as military cases.

342. Lastly, there was one area of agreement between Mr Cox and Mr Green: regardless of which method was chosen, all the diagnostics guidelines were merely guidelines, not tramlines. In every case, it would be necessary to take into account the entire clinical picture before reaching a diagnosis.

343. For the ENT experts, it was common ground in their joint report that the possibility of idiopathic hearing loss must be taken into consideration. A key challenge is that idiopathic sensorineural hearing loss can exhibit audiological configurations consistent with noise-induced hearing loss. In addition, it is possible for noise-induced hearing loss and idiopathic hearing loss to co-exist. However, the likelihood of hearing loss being idiopathic can be narrowed down in three ways. Firstly, idiopathic hearing loss does not follow the predictable pattern of deterioration seen in age-associated hearing loss. Secondly, specific causes of hearing loss from competing conditions (such as exposure to ototoxic drugs, ear infections, or a head injury) are usually apparent from the history

provided by the individual and/or the individual's medical records. Thirdly, the possibility of non-organic hearing loss can be objectively tested using cortical evoked response audiometry (CERA), which measures electrical activity in the brain's auditory cortex in response to sound stimuli.

344. Importantly, the joint report stated that idiopathic hearing loss is frequently seen in clinical practice, but there was less consensus as to what "frequently" meant. In oral evidence, Mr Cox elaborated upon his intended meaning, namely that a diagnosis is made in the majority of patients referred with hearing loss, but there are a significant number where that is not possible. In his section of the joint report, Mr Cox additionally commented that notching at 4 kHz in those without noise exposure or known medical causation is very rare in an otologically normal screened population, based on the international standard ISO 7029:2017/2024.

345. On the other hand, Mr Green in his section of the joint report relies on various studies to demonstrate the prevalence of idiopathic audiometric notches. For example, regarding notches at 4 kHz specifically, 21% of non-noise-exposed workers had notches at 4 kHz (for noise-exposed workers, it was 31%) according to Lie et al, "The Prevalence of Notched Audiograms in a Cross-Sectional Study of 12,055 Railway Workers", 2015 ("the Lie 2015 study") and 18.4% of subjects studied had audiometric notches at 4 kHz with no history of excessive noise exposure in Osei-Lah & Yeoh, "High frequency audiometric notch: An outpatient clinic survey", 2010 ("the Osei-Lah 2010 study"). More generally, the Lie 2015 study found notches at 3, 4, and 6 kHz in 53% of non-noise-exposed workers (for noise-exposed workers, it was 63%), and the Osie-Lah 2010 study found audiometric notches in 39.6% of 149 subjects that could not be attributed to noise. In cross-examination, Mr Cox agreed with the proposition that if there is a certain percentage across the population cohort who exhibit idiopathic hearing loss, there is no reason why that same percentage would not apply to a noise-exposed cohort as well.

Discussion

346. In my judgment, two of the diagnosis methods under consideration, namely the original M-NIHL and MLP(18), can be rejected in short order.

347. As Mr Platt for the Defendant submits, the original M-NIHL was superseded, two years after publication, by Prof. Moore's revised method, rM-NIHL. The latter test introduced modifications to the original; it did not purport to be a wholly new method. The rM-NIHL paper itself does not advocate continuing use of the M-NIHL method "as a cross-check, fallback or similar". Certainly, Prof. Moore does not advocate the use of the original test; he said in evidence "*I think the revised one is preferable, or I would advise using that in preference.*"

348. But it is not just that the revised test is the later one or the "preferred" one. The rM-NIHL paper identified specific and significant flaws in the M-NIHL method. Those flaws lead to poor specificity and a concomitantly high false-positive rate. The rM-NIHL paper itself states that the revised method is an improvement on the original one, in particular with respect to specificity/false positives. So, at p6 the paper reads "*It can be concluded that, in a medico-legal context, the rM-*

NIHL method has a better balance between sensitivity and specificity than the M-NIHL method."

349. In his generic report, Prof. Moore explains that certain aspects of the modifications made to the M-NIHL method in producing the rM-NIHL method (namely the final values of Mag(Notch) and Mag(ExcessHF) "*were chosen to improve on earlier methods*". And in his oral evidence Prof. Moore explained that: "*The original version of the test had poorer specificity than we would have liked… and, on the basis of that, I worked with some other people to try to develop and improve a revised method that had a better balance between sensitivity and specificity*" (emphasis added). He reiterated that the rM-NIHL method gave markedly higher specificity than the original method.

350. I unhesitatingly reject the suggestion that, all that notwithstanding, it might in certain cases be reasonable, if a case did not receive a diagnosis under rM-NIHL, to go back to the original method on the basis that it has a positive predictive value or 'PPV' greater than 0.5 (which, Prof. Moore said, indicates the balance of probabilities was met). It was deficiencies in the original method, notably its tendency to produce false positives, that prompted the revised method and it would be nonsensical, if not improper, to seek to advance a case on the basis of what has been shown to be a deficient test, merely because the better test did not produce the desired outcome.

351. In fairness to him, Mr Steinberg did not attempt to defend M-NIHL in its unrevised form. He was right not to do so.

352. The MLP (18) test is undoubtedly an interesting development. The idea of using machine learning to identify a medical condition is gaining support in other fields of medicine. But in my judgment, on the basis of current knowledge, it cannot safely or properly be deployed in litigation at the present time.

353. The fundamental difficulty is that it is not known precisely how the method works. In the paper introducing it, the authors acknowledge that "*A problem with the application of the MLP(18) method is that it is difficult to interpret exactly how it works*". In his joint report with Prof. Lutman, Prof. Moore said "*One criticism that might be made is that it is hard to understand how the MLP(18) method works*". In his evidence in Mr Craggs' case, he said "*The difficulty is in understanding how it works and interpreting what it's doing, and we can have some ideas about that, but we're not sure that we're seeing all the patterns that the network has identified*".

354. In the cross-examination of Prof. Moore, the following exchange took place:

> *Q. It gives a result, doesn't it, that you can't say why it has made a particular diagnosis in a given case? The output is still the black box?*
> *A. That is true. That is true.*
> *Q. So, for instance, an ENT surgeon who is using it couldn't – wouldn't be in a position to interrogate or challenge the result that comes out the other end?*
> *A. Well, no – they wouldn't – the result will come out positive or negative, they won't know why…*

Q. ...with the individual case of Mr Craggs, for instance – his Lordship would not be in a position to understand why that number has come out the other end, would he?
A. That's correct.

355. Mr Zeitoun made the same point during his evidence in Mr Craggs' case. He said:

> "*I do not understand the MLP method… Professor Moore kindly provided me with the spreadsheet to use... I don't know how it works…after I produced the supplementary [report in Craggs], I used it a tiny bit and (then) abandoned it, only for the reason I don't understand how it works. It may be a great method, but I don't know how it works. And my worry is, it gives a result, as well, which I cannot also challenge it and say, "Well, how did that result come?" Where it came from?"*

356. In my judgment, that inability to understand how a result was obtained, to interrogate the method to reveal its workings, makes MLP(18) entirely unsuitable as a means of establishing a case in litigation. For a judge to accept a diagnosis on the basis of MLP (18) would be a complete dereliction of duty. Unless the Court could be satisfied, on evidence, that the method was entirely reliable in every case, then it has at least to be possible for a Court to understand how the method produces the result where the outcome is disputed. The alternative would, furthermore, make an appeal against the conclusion impossible on any ground other than the total absence of underlying analysis, because the appellate Court would be equally unable to test the reasoning on which the conclusion was based.

357. That is sufficient to dispose of the point. But I also indicate that, if it were necessary, I would also accept the following additional arguments advanced by Mr Platt:

(i) The population on whom the method could be used was limited. Prof. Moore accepted that, because of the material on which the method was trained, the method could not be used on women, or men outside the age 29-60. A significant proportion of the men in the relevant cohort are aged over 60;
(ii) The populations on which the programme was trained were inadequate for the purpose. Prof. Moore used two databases to create MLP(18) (referred to by him as 'training and validation') and two to evaluate it. The training databases were referred to as MilDB1 and ContDB1, the testing databases as MilDB2 and ContDB2. MilDB1 and MilDB2 were composed of individuals who had noise exposure in the British military, whereas ContDB1 and ContDB2 comprised individuals from a German population not known to have had exposure to intense sounds. Prof. Moore trained MLP(18) to discriminate whether a particular set of data should be classified with MilDB1 (the Claimant group) or ContDB1 (the German group) but it cannot be said with any confidence that those persons in MilDB1 actually had any NIHL. As Prof. Lutman put it, "*it was suspected but not known whether the members of this group had actually sustained NIHL*".
(iii) The method did not discriminate sufficiently between those who had M-NIHL and those who had a history of noise exposure and worse hearing than average. It did not, in particular, rule out the possibility that this was

idiopathic hearing loss, a type of loss that occurs in a significant proportion of the population. In evidence Prof. Moore accepted that "*It's possible, it is always possible*" that a person who simply had poorer hearing than the median would be wrongly diagnosed positive by MLP(18). He added that, "*there is always a possibility that someone has always had bad hearing. That would be one reason why the test shows any false positives*".

358. During the evidence, I was particularly concerned with point (ii), the question whether the method depended on whether the MilDB1 group, a group of Claimants, had actually suffered NIHL or were merely alleging they had. During the course of the evidence I asked Prof. Moore about this.

> *MR JUSTICE GARNHAM: So what allowance was made for the fact that some Claimants might not be genuine?*
> *A. I mean, we didn't specifically allow for the fact that some Claimants might be faking in some way. There was no allowance for that.*
> *MR JUSTICE GARNHAM: Why not?*
> *A. As I said, given that we'd got a very high proportion of people in the noise-exposed group who received a positive diagnosis --*
> *MR JUSTICE GARNHAM: Using this method?*
> *A. Using this method, yes.*
> *MR JUSTICE GARNHAM: Well, that is bootstraps, isn't it? You are relying on what you are seeking to prove?*
> *A. It's not quite the same as bootstrapping. But, once you have the outcome that you have a very high sensitivity, then that implies in turn that the fact that you identified 98 per cent of that exposed group as having noise-induced hearing loss --*
> *Mr JUSTICE GARNHAM: That is the bit I don't get. How do you know that they had noise-induced hearing loss? Is it just the fact that they were exposed to it?*
> *A. They were exposed to noise and they were all making a claim. So that made it likely that a substantial proportion of them did have noise-induced hearing loss. Although they weren't selected according to whether –*
> *MR JUSTICE GARNHAM: Isn't there a real problem there that it may be either they were faking it altogether or that they had noise-induced hearing loss but it was due to non-military causes, like the fact that they had undeclared sporting activities that included use of firearms?*
> *A. Well, they had all been screened to exclude noise hobbies.*
> *MR JUSTICE GARNHAM: What happens if they weren't telling the truth?*
> *A. Well, I think it is rather rare for people not to tell the truth about that.*

359. I confess I did not find those answers reassuring. It appears that Prof. Moore was designing a machine learning diagnostic test for determining whether Claimants had M-NIHL which was based on an assumption that persons claiming damages for M-NIHL were indeed suffering M-NIHL.

360. Mr Steinberg's defence of MLP(18) was tepid at best. He said that MLP(18) was "*intended for use as a diagnostic tool as part of a clinician's assessment of the whole medical picture, a thorough history, and the exclusion of alternative causes*." He said that Prof. Moore had made clear in his oral evidence that, in a medico-legal context, it would inform the medical expert's judgement rather than

supplant it and "*the Claimants do not suggest, and have never suggested, that MLP(18) could or should be used in isolation.*" He concluded in his written closing that

> While MLP(18) is a useful parallel diagnostic tool in addition to the original and revised M-NIHL guidelines, its role is likely to assume increasing importance in the future as it is further refined (perhaps even with input from the Defendant) and work on deep neural networks continues. Ultimately, its purpose, in common with all the guidelines, is to assist in informing the expert's overall view.

361. It suffices to say that I reject the Claimants' case so far as it depends on MLP(18). In my judgment, it has not yet reached the stage where it provides support of any significant weight for a diagnosis reached on other grounds.

362. In those circumstances, the issue to be decided is which of CLB, devised in part by Prof. Lutman, and rM-NIHL, devised by Prof. Moore, is to be regarded as the better diagnostic tool.

363. I had submissions from both counsel to the effect that the expert instructed by their opponents had lost objectivity. Mr Platt did not suggest that Prof. Moore was seeking to mislead but he argued that "*his inherent biases*" informed his evidence. He argued that Prof. Moore (and also the ENT surgeon, Mr Cox) were "*emotionally, intellectually (and sometimes financially) too close to the case of the Claimants*". He said Prof. Moore's evidence appeared to be directed towards "*maximising compensation for hearing loss for the greatest number of Claimants*". He pointed out that Prof. Moore always acted for Claimants in medico-legal cases and that since 2017 most of his major academic publications appear designed to assist Claimants making compensation claims in a medico-legal context. Mr Platt said Prof. Moore used "*his various papers as a cumulative exercise which reinforces his views in the military hearing loss area*"; that his approach was always to prioritise sensitivity over specificity; that he took "*everyone and everything on the Claimants' side of the aisle at face value*"; and that he rarely finds that a Claimant has not sustained NIHL after he is referred to him.

364. Whilst purporting to distance himself from "*personal criticism*" of the experts and any suggestion this case amounted to "*a dual between Moore and Lutman*", Mr Steinberg advanced sustained criticism of Prof. Lutman. He said that Prof. Lutman had not "*maintained a substantial academic practice, he doesn't have a research programme, he hasn't supervised new empirical work or published primary research, save for the Lutman 2024 paper…and his present role is overwhelmingly as a medico-legal expert, almost exclusively instructed for defendants, if not entirely, and that background … shapes his perspective and his habits and what he brings to these questions*."

365. Having heard and seen both men give evidence over many days, I reject both these submissions about the experts. Both men are now highly respected emeritus professors, Prof. Moore of Auditory Perception at the University of Cambridge and Prof. Lutman of Audiology at the University of Southampton. It is clear that they are both heavily invested in their diagnostic method. They have each devoted

a significant part of the latter years of their professional lives to this issue. Both have written extensively on the subject. Both have devoted considerable time and energy to their evidence in these cases. It can fairly be said of Prof. Moore that he is almost always instructed by Claimants in NIHL cases and of Prof. Lutman that he is usually instructed by defendants and the emphasis he puts on different points appeared, on occasion, to change depending on the party instructing him. But in my judgment, none of this significantly undermines the evidence of either expert, still less would it support a conclusion that either was acting other than in good faith. In my judgment, both men were giving me their honest opinion and doing their best to assist me on the issues before the Court. Accordingly, the determination of this issue will turn on the competing merits of the alternative methods, rather than a resolution of the personal attacks on the witnesses.

366. Mr Platt says CLB has a flexibility and lack of restriction that the ‘Moore methods’ lack; it is more personalised to the individual; it includes modifying factors that are absent from the ‘Moore methods’; it yields a lower ‘false positive’ rate than the Moore methods; experts instructed by the Claimants (save for Prof. Moore) use CLB in military cases on occasions; and the purported problems identified by the Claimants with CLB are either equally applicable to the Moore methods, illusory or overstated. Consideration of the CLB in the context of the lead Claimants shows that it works well.

367. I accept that CLB has its advantages. I accept that it can more easily be personalised for those within its scope and that it has been widely used in medico-legal practice since the publication of the CLB paper in 2000, including on occasions by experts instructed by the Claimants. But what concerns me is the scope of CLB and its applicability in military cases.

368. It is common ground that the type of noise to which a person is subject affects the type of hearing damage they suffer. Professors Moore and Lutman agreed that military noise exposure may include unprotected exposure to high-intensity impulses, for example from firing riles or machine guns and that “*it has been recognised for decades that impulsive noise tends to be more damaging than steady noise having the same overall energy.*”

369. But it is not just that impulsive noise is more damaging, it is also of a different nature from that caused by steady-state broadband noise, the sort of noise commonly experienced in factories. The ENT experts explain in the judicial primer that:

> There are pathological differences in the pattern of damage caused by exposure to repetitive steady-state broadband noise, and the damage caused by impulsive noise and acoustic trauma. It is accepted that exposure to loud steady-state broadband noise over extended periods of time, often decades, from industrial exposure to noise, results in damage to the outer hair cells (OHCs) in the cochlea that respond to frequencies at, and adjacent to 4 kHz …
> The damage to the cochlea from intense impulsive noise … is different. In addition to the outer hair cell damage, there may be structural damage to other parts of the cochlea including the inner hair cells and the supporting cells of the organ of Corti. The organ of Corti may become detached from

the basilar membrane. There can in some cases also be damage to the ear drum and ossicular chain. Intensive impulsive noise is often of short duration, and so the lag in the initiation of the protective effect of the acoustic reflex may not allow protection of the cochlea from the full impulse of noise energy.

370. Those differences in the type of damage, the severity of the damage and the mechanism of the damage are commonly reflected in differences in the audiograms produced when the individual concerned is tested. The ENT experts agreed that "*the damage to the ear from exposure to intense impulsive sound is not the same as from chronic broadband steady state noise (with no impulsive exposure) and the audiometric pattern of hearing loss can be different*." Prof. Lutman also agreed with that assessment in his oral evidence.

371. Those differences in the resulting audiometric pattern are explained by the fact that, as was described in the Judicial Primer, different regions of the cochlea are tuned to different frequencies, and so hearing loss varies with frequency depending on which regions of the cochlea are damaged.

372. I accept Mr Steinberg's submission that there are four different ways in which the audiometric manifestation of military NIHL tends to differ from that of typical industrial NIHL. First, maximum losses are more frequently found at 6 kHz. That was agreed by Lutman and Moore in their joint report:

> Observational studies suggest that the frequency of maximum NIHL in military cases tends to be higher than 4 kHz in many cases. Therefore, the mechanism of damage may not be the same in all respects for steady sound of moderately high level and impulsive sounds with very high peak levels. Partly, the difference may arise because the frequency spectrum of some military noises (e.g., rifles) contains substantial high-frequency energy. The reasons for the difference are not fully understood

373. Prof. Lutman agreed this in cross-examination:

> *Q. ... The nature of the damage may be different such that it produces a different audiometric pattern. Do you agree with that?*
> *A. I think there are some differences. There is evidence to suggest that, particularly in younger people and with milder cases, the maximum noise-induced hearing loss caused by exposure, such as to rifle fire, may first appear at 6 kilohertz rather than 4 kilohertz*

374. That is also consistent with a leading textbook 'Noise and its Effects' (2007) where the authors of the chapter on 'Military Noise-Induced Hearing Loss' concluded that

> Most probably, the earliest and most common audiometric feature of M-NIHL is 6-to 8-kHz loss, which with continuation of exposure, affects the lower frequencies, particularly 3-4 kHz.

375. The second way in which the audiometry of military NIHL differs from that typical industrial NIHL is the variable effect of military noise damage. That was

the evidence of Prof. Moore, and Prof. Lutman agreed in cross-examination that the frequency at which the hearing loss is greatest can vary across individuals.

376. Third, in military cases there is greater impact on hearing thresholds at 1 and 8 kHz than is the case in industrial cases. Mr Green told me that military NIHL generates damage at 8 kHz more frequently than industrial NIHL:

> *Q. I don't think anybody is saying that military noise can't produce notches or damage at 3 and 4, but, as you have said, more often than in the cases of industrial noise, you will see the damage at 8 kilohertz, won't you?*
> *A. Yes. You can see more damage at 8, but you are still seeing notches and bulges, and you may see more bulges than notches because the effect of 8 kilohertz going down can often lose a notch. But you are still seeing the bulges.*

377. Prof. Lutman agreed that military NIHL can affect 8 kHz:

> *Q. So, even if you don't accept the maximal damage is likely to occur at 8-kilohertz, it's right that military noise can affect that frequency, can't it, 8 kilohertz?*
> *A. Yes.*

378. And the agreed evidence was that military noise can affect the lower frequencies as well. The following exchange took place during Prof. Lutman's cross examination:

> *Q. We also know, don't we, that military noise can cause low-frequency hearing loss, can't it?*
> *A. Well, low-frequency noise exposures in general can cause lower-frequency noise-induced hearing loss, yes.*

379. Fourth and finally, there is a higher prevalence of asymmetrical loss in military cases.

380. In the NIHL Primer, Mr Cox and Mr Green explained that in military NIHL "*significant hearing asymmetry is common, if not the norm*." That typically affects the left ear more than the right. The reason for that is not contentious. The standard British Army service rifle (the SA80) must be fired from the right shoulder, regardless of an individual's dominant hand. Research conducted for the Defendant by Paddan and Lower, 'Factors affecting sound exposure from firing an SA80 high-velocity rifle' demonstrated that the left ear is exposed to higher sound pressure when the rifle is fired due to a "head shadow effect":

> The median peak sound pressure at the left ear of the firer was approximately 2.4 dB higher than that measured at the right ear. This difference in sound pressure levels is thought to be due to the 'head shadow effect' whereby the left ear is in direct line with the muzzle of the weapon and the right ear is shielded by the head

381. Mr Steinberg reminds me that 2.4 dB corresponds to almost twice as much energy at the left ear than at the right ear.

382. By contrast, asymmetry is uncommon in general industrial noise exposure. In the textbook, 'Medical-Legal Evaluation of Hearing Loss', Dobie explained that the rate of asymmetry in occupationally exposed people matched those not exposed:

> Audiometric asymmetry is no more frequent in occupationally noise exposed men than in non-noise-exposed men (Dobie, 2014) but is frequently seen in people who shoot rifles and shotguns.

383. Mr Steinberg also pointed me to an article by Dobie on this subject entitled '*Does Occupational Noise Cause Asymmetric Hearing Loss?*' The conclusion was that "*Occupational noise exposure does not usually cause or exacerbate audiometric asymmetry.*"

384. Accordingly, I find that the type of noise is different in the typical military case than in the normal industrial case, severity of the resulting damage may be different, the mechanism of damage may be different, and the audiometric presentation may be different. The critical question that follows is whether, nonetheless, CLB is a suitable method for diagnosing M-NIHL.

385. Mr Platt accepts that CLB, as written, is limited in its scope to "*For the most part… uncomplicated cases of NIHL; that is, cases of 'typical' NIHL together with presumed 'normal' AAHL. In the present context, 'typical' NIHL refers to the form of hearing impairment that gradually accrues in a proportion of those who have repeated exposures to hazardous levels of one or more of the common types of broad-band sound*". But he says that does not mean that it cannot or should not be used in military cases.

386. He acknowledges that Prof. Lutman explained in his generic report that the principle adopted by the authors of CLB "*was to set the scope of the guidelines to be the same as the scope of the evidence base and not extrapolate beyond that"*. But as he pointed out, Prof. Lutman went on *"That is not the same as stating that the guidelines do not apply beyond the evidence base; rather, there was lack of sufficient evidence to extrapolate beyond the evidence base*".

387. Prof. Lutman explained in the joint report, that the "*critical audiometric requirement of the CLB guidelines for a diagnosis of NIHL is a "notch" or "bulge" in the frequency range 3-6 kHz of at least 10 dB".* But, as is common ground, life in the military may expose personnel to highly impulsive noise and as is shown above that may result in different audiometric presentations. In their joint statement, Professors Moore and Lutman agreed that such cases "*may display a pattern that is shifted towards higher frequencies, and sometimes no notch or bulge is apparent.*"

388. Mr Green agreed that the propensity of impulsive weapon fire to cause more damage at 6 and 8 kHz was a potentially confounding factor which had to be looked at very carefully. He agreed that damage at 6 kHz and 8 kHz makes the application of the CLB method difficult: "*Where there is significant hearing loss at 6kHz and 8kHz, the presumed age associated hearing loss may be exaggerated using CLB and LCB. A diagnosis of noise damage may not be made in the absence of auditory notches or bulges.*" More fundamentally, he agreed that CLB (and

possibly LCB too) "*breaks down*" or "*doesn't work*" where the loss is at higher frequencies [Day 21 – 75:4 -76:11].

389. In his oral evidence Mr Cox explained the difficulty:

> *MR PLATT: ... But you will be aware, as was confirmed by Professor Lutman, and just from reading the LCB and CLB we can see, CLB can diagnose hearing loss at 6 kilohertz as well.*
> *A. At 6 kilohertz referenced to the threshold at 8 kilohertz, not at 6 kilohertz in isolation. So, to have a notch or bulge at 6 kilohertz, you would have to have a better hearing threshold at 8 kilohertz by 10 decibels if it was for a notch. That isn't the pattern. Often, if there is significant loss at 6 kilohertz, there is similar or sometimes even greater loss at 8 kilohertz. So you may ... hearing loss at 6, which, had there been normal hearing or preserved hearing at 8, would have represented audiometrically as a notch or a bulge, but if you have hearing loss at 8, then that indicator of noise damage used in CLB disappears.*

390. In the joint statement Prof. Moore explained that "*Not infrequently, serial audiometry shows cases where a notch or bulge is apparent at a certain time, but subsequently disappears because of worsening of hearing at 6 and 8 kHz. Therefore, the absence of a notch or bulge cannot be taken as indicating an absence of M-NIHL.*"

391. In cross-examination, Prof. Lutman accepted that a worsening at 8 kHz can change the diagnosis from positive to negative when the damage is centred at 6 kHz:

> *Q. You have also agreed with me that a notch or bulge might disappear in this way because of a worsening of the levels at 8 kilohertz; correct?*
> *A. Yes.*
> *Q. That could flip the diagnosis from positive to negative; correct?*
> *A. Yes.*

392. Furthermore, he accepted that, at least on its face, CLB does not take into account the fact that military noise may cause damage at 8 kHz.

> *Q. But what I suggest to you is that, particularly at 8 kilohertz, there is good evidence, good scientific evidence that the damage in military cases may be done at 8 kilohertz. How does CLB take into account that fact?*
> *A. It doesn't take it into account specifically.*

393. None of that is intrinsically surprising; CLB was not designed to take into account high impulse noise.

394. In his generic report, Prof. Lutman advances an argument that the CLB guidelines can be extrapolated to apply to military noise exposure "*despite lack of quantitative underpinning evidence*". He says:

> The scope limitations of the CLB guidelines are detailed in Section 2 of the guidelines. They do not address the question of what to do in cases that are

> outside the scope (e.g., non-typical noise exposure). In my opinion, extrapolation of the guidelines to apply to non-typical exposures, despite lack of quantitative underpinning evidence, is a reasonable approach, in the absence of a compelling alternative.

395. Prof. Lutman says that the "*underlying physiological principles of NIHL apply equally to typical and non-typical noise exposures, accepting that traumatic exposure to very high intensities is very different from the gradually progressive hearing loss arising from cumulative noise exposure in the vast majority of cases*."

396. The difficulties with that are three-fold. First, the CLB guidelines were not designed for M-NIHL; that was not the 'typical' NIHL described in the CLB paper, which, as noted above, "*refers to the form of hearing impairment that gradually accrues in a proportion of those who have repeated exposures to hazardous levels of one or more of the common types of broad- band sound*". Prof. Lutman accepted that that was the case.

397. Second, as explained above, the mechanism of damage of M-NIHL may well be different. In fact, in the generic joint statement Prof. Lutman agreed that the underlying physiological principles did not apply equally to cases of military noise. He said:

> Military noise exposure may include unprotected exposure to high-intensity impulses, for example from firing rifles or machine guns. In such cases, mechanisms of NIHL may be somewhat different from those occurring for less impulsive noise.

398. Mr Green agreed in oral evidence (day 21 at 9.20). The relevant exchange is as follows:

> *Q. Professor Lutman stated that it would be reasonable to apply CLB, despite the lack of quantitative underpinning evidence, because the physiological principles apply equally. But you say that there are pathological differences and you accept that, don't you?*
> *A. I think that is what we say here, yes. Yes.*

399. Third, as also explained above, the effect of the damage on the ear and the audiometric consequences are potentially very different.

400. In those circumstances, it is very difficult to see how the CLB guidelines can be extrapolated to apply to military noise exposure.

401. Mr Platt sought, in the course of his cross-examination of Mr Cox, to develop an argument that the CLB could be modified by reference to the LCB paper on quantification where there was evidence on the audiograms of damage at 8 kHz. He suggested that it may be appropriate when <u>diagnosing</u> NIHL to select a new threshold value for 8 kHz based on the overall trend for age-associated hearing loss. In my judgment, however, it is entirely unsatisfactory to replace the objectively measured HTL level at 8 kHz of an individual with an age-expected hearing loss (which would show better hearing at 8 kHz than military Claimants) simply to try to uncover whether he has a specific type (i.e. military-caused) of

hearing loss. A method that has to do that in most cases, rather than exceptional ones, is unsustainable.

402. But perhaps the overwhelming obstacle to that approach is that, as Mr Steinberg observes, in his written evidence Prof. Lutman "specifically and emphatically" ruled out using this 'alternative approach' in relation to diagnosis. In his generic report he said:

> An alternative approach to estimate the 'but for' case might be to rely on population data for age associated hearing loss, where it is necessary to both choose an appropriate database for age associated hearing loss and select an appropriate percentile... <u>Note that this approach applies to quantification and does not apply to diagnosis</u>

403. His reference to the "but for" case underlines the point that he is here considering quantification, not diagnosis.

404. In my judgment, the inevitable conclusion is that CLB is not a suitable method of diagnosing NIHL in cases where it is possible that the individual was exposed to the sort of noise typically experienced by members of the armed forces.

405. I turn then to the one remaining candidate for that function, rM-NIHL.

406. As noted above, rM-NIHL was the revision of the M-NIHL method set out by Prof. Moore and others in the September 2022 paper, "*Modification of a Method for Diagnosing Noise Induced Hearing Loss Sustained During Military Service"*. Mr Steinberg says that a "*striking feature of the … rM-NIHL guidelines is their similarity to the CLB guidelines. The key difference between them, however, is that they have been designed and adapted for use in military cases*." He says that it is important to appreciate that all other plausible causes of hearing loss apart from noise must be ruled out for a diagnosis of military NIHL to be made. A detailed and stringent approach to 'medical history' is set out in Moore et al (2022), which is incorporated by reference into the rM-NIHL method.

407. The objections advanced by Mr Platt to the deployment of rM-NIHL can be summarised as follows:

(i) Its requirement R1 (which is the same as for the M-NIHL method) is too permissive and will be satisfied in a huge number of cases.
(ii) Its requirement R2a is somewhat similar to requirement R3 of CLB, in that it looks for a bulge at 3, 4 or 6 kHz. However, R2a is vulnerable to false positives because under rM-NIHL no correction is made at 6 kHz for TDH39P headphones. Further, R2a is, as written, tied to median AAHL under ISO 7029:2017 and without any baseline correction. (It will be remembered that I have found that some baseline correction will be required).
(iii) Its requirement R2b is problematic because it is simply high frequency hearing loss which includes a certain amount greater than the median (under standard 2017/2024 without baseline correction), which will occur in many people in any event. The difficulty is then deciding whether the reason for that worse result is noise exposure or some idiopathic cause.

(iv) In general, the specificity of rM-NIHL, though better than that of M-NIHL, is worse than CLB. False positives remain a difficulty.

(v) rM-NIHL is apparently limited by age and sex, though Prof. Moore's evidence on this has not been consistent. rM-NIHL is presumably also limited by audiometric characteristics on entry to the armed forces.

408. I deal with each in turn.

409. In my view, there is no merit in the first or second objection. Prof. Lutman accepted in his generic report that the application of requirements R1 and R2a of rM-NIHL will in principle give rise to a valid diagnosis of NIHL.

410. As to the third point, Mr Platt argues that Prof. Moore's approach to this issue is just to ignore the possibility of idiopathic hearing loss. Prof. Moore said in evidence that idiopathic hearing loss "*would be rather rare, so, on the balance of probabilities, if someone shows a hearing loss and they have had noise exposure and they meet the criteria of the test, it is more likely that that was due to the noise exposure than due to the idiopathic loss, because it is common for noise exposure to lead to hearing loss, it is not common for someone to have perfectly normal hearing and then, over a period of a few years, without noise exposure, to develop an idiopathic hearing loss*".

411. But, says Mr Platt, you cannot just ignore idiopathic hearing loss. He points to the agreed evidence of Mr Cox and Mr Green in their generic joint report:

> Hearing can be affected by idiopathic or 'unknown' causation. In any assessment of hearing loss in a medico legal context, an Expert must be mindful of the possibility of an idiopathic hearing loss in addition to, or instead of hearing loss of known or likely causation. Idiopathic hearing loss is frequently seen in clinical practice.
>
> Specific causes of hearing loss are usually apparent from the history obtained and/or the individual's medical records. In cases where no cause is identified, the hearing loss above that expected for age, will most likely be due to a combination of genetic and environmental factors... Idiopathic hearing loss can present as a sudden hearing loss or with deterioration in thresholds over many years. It does not follow the predictable pattern of deterioration seen in age related hearing loss. Within the context of diagnosing NIHL, idiopathic hearing loss must be taken into consideration. Sensorineural hearing loss that is non- age related can exhibit audiological configurations consistent with NIHL. It must also be considered that NIHL and idiopathic hearing loss can coexist and the presence of an additional cause of sensorineural hearing loss does not preclude a diagnosis of NIHL.

412. In my view, if this requirement stood alone or was an element of a determinative clinical test, this would be an argument of substance. Idiopathic hearing loss is a real phenomenon which has always to be given careful consideration by the diagnosing clinician as an alternative explanation for the hearing loss. But this requirement does not stand alone and is an element of a set of guidelines, not a determinative clinical test.

413. As Mr Steinberg correctly submits "*military audiometry, for all its flaws, will at least alert an ENT expert if someone appears to have unusually poor hearing from the time they enlisted into the armed forces*." Mr Cox was asked about the possibility of "*audiometric mimicking*" by idiopathic conditions. His response was that this does happen, but that the conditions causing such mimicking are usually identifiable on referral, so that they are no longer idiopathic.

414. In his generic report, Prof. Lutman accepted that satisfaction of R2b may, on occasions, justifiably lead to a positive diagnosis despite the audiometry failing to meet the CLB criteria provided that it is taken into account against a careful evaluation of the whole clinical picture by a medical expert:

> …there will be cases where CLB guidelines are not met but the M-NIHL method suggests a positive diagnosis. Some cases will be where there are indications of NIHL only on one ear. However, other cases will be those where requirement R2a of the M-NIHL guidelines is not met and the positive diagnosis arises from requirement R2b, which simply indicates that there is greater hearing loss at high frequencies than expected for men or women of the same age by a certain margin. Clearly that criterion is not specific to NIHL (as opposed a notch or bulge). The difficulty faced by the medical expert is to determine whether that hearing loss has arisen from the alleged unprotected noise exposure, or from some other causation that may be unknown, bearing in mind that sensorineural hearing loss of unknown origin (idiopathic) is common in the general population with prevalence increasing with age. In some cases, the history of progression of hearing loss may be sufficiently compelling that the medical expert considers that NIHL is more likely. In other cases, there may be lack of any sound basis from which to conclude that there is a probable diagnosis of NIHL, as opposed to idiopathic hearing loss.

415. In my view, there is nothing in this objection.

416. I have dealt in the sub-chapter dealing with specificity and sensitivity with Mr Platt's fourth objection. Specificity and sensitivity calculations, and more particularly the PPV figure, are a useful part of the diagnostic process, but they are not decisive. They do not justify the rejection of rM-NIHL as useful diagnostic tool.

417. Finally, it is right to observe that rM-NIHL is limited by age and sex. It may also be limited by audiometric characteristics on entry to the armed forces in the sense that these may displace what would otherwise be the conclusion on the application of rM-NIHL. But none of that justifies the rejection of the method in the generality of military deafness cases.

418. I conclude, on the basis of all the evidence I have heard, that Mr Steinberg is right when he submits that military NIHL can present without a CLB notch/bulge and the absence of a notch does not exclude NIHL, that military noise commonly affects hearing at 8 kHz and this can erase or disguise a notch or bulge; and that military impulse noise tends to produce a different and more variable audiometric pattern than steady state noise.

419. It follows, first, that the original M-NIHL method and the MLP(18) method should not be relied on in medico-legal work (see [346] above and following); second, that CLB is not generally suitable for military cases and third that the rM-NIHL method is the method to be preferred. A proper diagnosis of NIHL depends on the careful application of each element of the rM-NIHL test.

Chapter 9 – Quantification of NIHL

420. This chapter considers how military NIHL should be quantified. I first set out the conclusions the parties invite me to reach and the essential elements of the two quantification methods. Then I consider the quantification method to be preferred; the correct approach to selecting the percentile; the relevant frequencies to be considered; and the correct approach to asymmetry.

421. I begin, however, by pointing out that at this stage of the analysis, the Defendant is at the obvious disadvantage in that I have found against them on the previous issue, the diagnostic method to be preferred. That is significant because, as pointed out below, LCB describes itself as an extension to CLB.

The Competing Cases

422. The Claimants invite the Court to reach the following conclusions:

- The method of quantifying hearing loss described in Lutman, Coles and Buffin in 2015 ("LCB") is not a reliable method for quantifying military NIHL and is not fit for purpose in military cases.
- LCB provides no workable or reliable guidance to rectify the problem of noise induced damage at 6 to 8 kHz, which often arises in military cases.
- The Court should adopt a percentile-based approach as recommended by the M-NIHL or rM-NIHL method.
- Military NIHL should be quantified by comparing measured hearing threshold levels with what would be expected at the relevant age based on ISO 7029:2017/2024.
- Where no reliable pre-exposure audiogram exists, the 50th percentile is the fair default.
- A fixed 4 to 1 ratio for binaural average weighting can understate disability where loss is asymmetric.

423. The Defendant invites the Court to conclude:

- The quantification method proposed in LCB should be preferred for the quantification of military noise induced hearing loss over that proposed by Prof. Moore. In cases where there is a clear additional loss of hearing at 8 kHz, an adjustment should be made to the measured hearing threshold level at 8 kHz in accordance with the recommendation made at Appendix 2 of the LCB paper.
- In order to determine the overall quantification of NIHL, an appropriate percentile should be selected based on the hearing of the individual ascertained from all of the available audiometry.
- In outlier cases involving noise damage at 8 kHz, this may involve using the exception clause in LCB.
- Overall hearing disability should ordinarily be calculated by reference to the average hearing thresholds over 1, 2 and 3 kHz.
- Where the medicolegal ENT surgeon determines that only one ear meets the criteria for diagnosis of NIHL, it will not usually be appropriate to quantify NIHL in the ear which does not meet the diagnostic threshold.

The Two Methods

424. The Lutman, Coles and Buffin ("LCB") paper of 2015 describes itself as "… an extension to the [CLB] guidelines that allows the noise induced hearing loss component to be estimated quantitatively."

425. It quantifies hearing loss in the following way:

> The procedure proposed here for quantification of the noise-induced hearing loss component comprises two passes: Pass One entails carrying out bulge calculations as per the original Guidelines methodology (even where the diagnosis of noise-induced hearing loss was based on a significant notch rather than a bulge). Pass Two is additional and involves the following four steps:
>
> 1 Estimate the extent to which the anchor points include some noise-induced hearing loss.
>
> 2 Make corresponding alterations to create modified anchor points.
>
> 3 Fit a modified age-associated hearing loss contour to the modified anchor points using the same approach as defined in the Guidelines.
>
> 4 Quantify noise-induced hearing loss as the difference between the measured thresholds and the modified age-associated hearing loss contour (setting negative differences to zero).

426. Mr Platt helpfully explained the operation of the LCB method by applying it to the medicolegal audiometry of Mr Michael Evans. I reproduce his explanation in the following 10 paragraphs:

1 **PASS TWO**

Right ear	250 Hz	500 Hz	1 kHz	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz
Hearing threshold level	10	10	10	10	30	40	40	20
Modified anchor points			7					11
Selected AAHL statistics			0	3	5	9	10	12
Misfit values			7					-1
Interpolated misfit values			7	4.0	2.7	1.3	0.1	-1
Modified AAHL values			7	7.0	7.7	10.3	10.1	11
Modified bulge			3	3.0	22.3	29.7	29.9	9
Estimated AAHL			7	7.0	7.7	10.3	10.1	11

2

Left ear	250 Hz	500 Hz	1 kHz	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz
Hearing threshold level	15	10	10	25	40	50	45	35
Modified anchor points			6					26
Selected AAHL statistics			5	9	12	18	20	24
Misfit values			1					2
Interpolated misfit values			1	1.3	1.5	1.7	1.8	2
Modified AAHL values			6	10.3	13.5	19.7	21.8	26
Modified bulge			4	14.7	26.5	30.3	23.2	9
Estimated AAHL			6	10.3	13.5	19.7	21.8	26

3

427. Following the calculation for the left ear, Pass Two of LCB begins by identifying the frequencies measured by the audiogram and setting out the measured hearing threshold levels:

Left ear	250 Hz	500 Hz	1 kHz	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz
Hearing threshold level	15	10	10	25	40	50	45	35

428. Anchor points at 1 and 8 kHz are selected and modified to take account of any noise induced component as there may be at the given anchor point:

	250 Hz	500 Hz	1 kHz	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz
Modified anchor points			6					26

429. The user of the Guidelines establishes, based upon the modified anchor points, the appropriate percentile from the applicable ISO database. Age associated hearing loss (AAHL) statistics for each frequency are identified from the database and set out:

	250 Hz	500 Hz	1 kHz	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz
Selected AAHL statistics			5	9	12	18	20	24

430. Misfit values are calculated by subtracting the value at the modified anchor points from the selected AAHL values at the anchor points. Interpolated misfit values are then calculated for each frequency between the anchor points using a formula set out in the LCB paper:

	250 Hz	500 Hz	1 kHz	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz
Misfit values			1					2
Interpolated misfit values			1	1.3	1.5	1.7	1.8	2

431. The interpolated misfit values are added to the age associated hearing loss values in order to tailor the age associated hearing loss data to the individual:

	250 Hz	500 Hz	1 kHz	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz
Modified AAHL values			6	10.3	13.5	19.7	21.8	26

432. The bulge is then calculated by subtracting the AAHL figure from the measured threshold:

	250 Hz	500 Hz	1 kHz	2 kHz	3 kHz	4 kHz	6 kHz	8 kHz
Modified bulge			4	14.7	26.5	30.3	23.2	9

433. The AAHL figures are set out again on the final line.

434. The bulge figures at 1, 2 and 3 kHz (in this instance 4, 14.7, 26.5) are extracted from the table and used to calculate overall disability:

1, 2, 3 kHz calculations

The better hearing ear is the right ear.

Right ear average excess loss	9.6 dB
[Calculation: (3.5 + 3.0 + 22.3) ÷ 3]	
Left ear average excess loss	15.1 dB
[Calculation: (4 + 15 + 27) ÷ 3]	

435. The binaural average is then calculated to determine the individual's overall hearing loss:

Calculation: (4 x hearing loss in **better ear**) + (1 x hearing loss in **worse ear**) ÷ 5

Binaural NIHL (4 x 9.6 + 1 x 15.1) ÷ 5

1, 2, 3 kHz average excess loss is 10.7 dB

1, 2, 3 kHz summary

Average binaural hearing loss	18.3 dB
Average binaural AAHL	7.6 dB
Average binaural excess loss	10.7 dB

436. It follows that the LCB method quantifies NIHL essentially from the magnitude of the notch/bulge, with some addition to account for the likely component of NIHL at the "anchor points" of 1 and 8 kHz. The method was founded on a model of NIHL where the maximum notch/bulge is at 4 kHz and is most accurate in cases where that occurs. It is less accurate when the notch/bulge has a maximum at other frequencies. The method is only applicable to cases where the CLB requirements have been met, in which case there must be a material notch/bulge in at least one ear.

437. In 2022, Prof. Moore, Mr Cox and another ENT surgeon, David Lowe, produced an alternative method for quantifying NIHL as part of their paper, *Guidelines for Diagnosing and Quantifying Noise-Induced Hearing Loss* ("the MLC paper").

438. The abstract of the MLC paper reads as follows:

> This paper makes recommendations for the diagnosis and quantification of noise-induced hearing loss (NIHL) in a medico- legal context. A distinction is made between NIHL produced by: steady broadband noise, as occurs in some factories; more impulsive factory sounds, such as hammering; noise exposure

during military service, which can involve very high peak sound levels; and exposure to very intense tones. It is argued that existing diagnostic methods, which were primarily developed to deal with NIHL produced by steady broadband noise, are not adequate for the diagnosis of NIHL produced by different types of exposures. Furthermore, some existing diagnostic methods are based on now obsolete standards, and make unrealistic assumptions. Diagnostic methods are proposed for each of the types of noise exposure considered. It is recommended that quantification of NIHL for all types of exposures is based on comparison of the measured hearing threshold levels with the age-associated hearing levels (AAHLs) for a non-noise exposed population, as specified in ISO 7029 (2017), usually using the 50^{th} percentile, but using another percentile if there are good reasons for doing so. When audiograms are available both soon after the end of military service and sometime afterwards, the most recent audiogram should be used for diagnosis and quantification, since this reflects any effect of the noise exposure on the subsequent progression of hearing loss. It is recommended that the overall NIHL for each ear be quantified as the average NIHL across the frequencies 1, 2, and 4 kHz.

439. In the section headed "*Quantification of NIHL*" the authors indicate that their proposed method depends on a positive diagnosis using the diagnostic methods described in the paper. They continue in the section directed to "*Exposure to Noise During Military Service*":

> In our opinion, the most appropriate method for quantifying M-NIHL is by comparison with the HTLs expected from the 50^{th} percentile of ISO 7029 (2017), as described above.
> In some cases, it may be appropriate to use a percentile other than the 50^{th}. Reasons for doing this are:
> 1. There are one or more reliable audiograms obtained prior to the start of noise exposure that indicate markedly worse or better hearing than average. If so, the percentile should be based on the pre-exposure audiogram(s).
> 2. A recent audiogram shows HTLs at one or more frequencies that indicate hearing better than the 50^{th} percentile for that individual's age. For example, if a 47 year old man shows an HTL at 8 kHz of 10 dB HL, corresponding to the 65^{th} percentile in ISO 7029 (2017), then it would be appropriate to use the 65^{th} percentile.
> 3. If one ear has markedly better hearing than the other ear, it is appropriate to base the choice of percentile on the HTLs for the better-hearing ear.
>
> The use of a higher (better) percentile will increase the estimated M-NIHL, while the use of a lower (worse) percentile will decrease the estimated M-NIHL…
>
> In summary, M-NIHL, like NIHL associated with exposure to steady broadband sounds, should be quantified by comparison to AAHL values taken from ISO 7029 (2017), using the 50^{th} percentile unless there are good reasons to choose a different percentile.

440. It follows that the method of quantification proposed in association with the M-NIHL, rM-NIHL and, later, the MLP(18) is based on the extent to which hearing threshold levels (HTLs) exceed a given percentile of age-associated hearing loss. The user of this method is free to choose the normative reference, although standard 2017/2024 is suggested and in practice, 2017/2024 is virtually always used. The user of this method is able to choose the percentile for comparison and suggestions are made on how that decision may be taken. It is suggested to use the 50th percentile as the default.

The Appropriate Method

Competing Submissions

441. Mr Platt argues that the LCB method should be preferred over the Moore quantification method for three reasons. First, it "*is tailored to the hearing abilities of the individual, such that the overall hearing loss calculation, and the proportion of hearing loss attributed to noise, takes proper account of the "but for" scenario*". Second because in so doing, LCB takes some account of the potential for idiopathic loss. Third, because, whilst it is accepted that LCB is most accurate when the notch/bulge is at 4 kHz, there is a clear means of modification for scenarios in which there is clear evidence of significant NIHL at 8 kHz, which retains the tailored approach and produces a bespoke and realistic outcome.

442. Mr Platt's criticism of the Moore method focused on the role of the referent percentile and the frequencies to be used rather than the inherent strengths and weaknesses of the competing models.

443. Mr Steinberg argues that there are three reasons why LCB systemically fails properly to quantify NIHL caused by exposure to military noise. First, he says that military NIHL may not involve a notch or a bulge on an audiogram. Second, he says that military NIHL is often maximal at 6 kHz or greater. And third, he argues that the LCB method estimates NIHL at the anchor points of 1 and 8 kHz on the basis of the typical pattern of industrial NIHL, which is not applicable to military NIHL. He argues that the Moore method avoids all these difficulties.

The Evidence

444. Professors Lutman and Moore gave evidence in support of their respective papers, LCB in Prof. Lutman's case, MLC in Prof. Moore's. However, during the course of his evidence in this case, Prof. Lutman made concessions which support Mr Steinberg's case as summarised above.

445. The first concession concerned the significance of a notch or bulge on an audiogram. It was common ground between Professors Lutman and Moore that some cases of NIHL in the military produced audiograms without the notches or bulges typical in cases where a Claimant had been exposed to steady state noise. They agreed that:

> Military cases where there has been exposure to highly impulsive noise may display a pattern that is shifted towards higher frequencies, and sometimes no notch or bulge is apparent. In some cases, a notch or bulge may be

apparent in a given audiogram that on later audiometry disappears because of a worsening of hearing at 8 kHz.

446. There is no attempt in the LCB paper to cater for this, and Prof. Lutman agreed that the LCB method cannot be applied to cases where there is no notch or bulge:

> The method is only applicable to cases where the CLB requirements have been met, in which case there must be a material notch/bulge in at least one ear. The method leads to an estimate of zero or even negative amount of NIHL if applied to cases where there is simply excessive hearing loss at high frequencies, as can occur in cases when condition R2b of the M-NIHL or rM-NIHL methods is met but condition R2a is not met.

447. In consequence, Prof. Lutman was compelled to assert that an "alternative approach" to the LCB guidelines is required in cases of military NIHL where there is no notch or bulge:

> In rare cases where there is no notch or bulge at all, yet a diagnosis of NIHL is upheld, an alternative approach may be required.

448. When Prof. Lutman was asked whether he could provide any guidance on his suggested "alternative approach", the following exchange took place.

> *A. Clearly, there are going to be cases for which any guidelines are not completely appropriate. It is up to the medical expert to use guidelines as they think fit and in cases, particular cases, to take other considerations into account as they see fit.*
> *Q. What you talked about in your report was some kind of slight adjustment, unspecified slight adjustment, where the loss doesn't comply with the CLB model. But you are unable to provide any guidance on that, because, for you, it is a complete unknown, isn't it?*
> *A. Well, every case is different and needs to be decided on its merits.*

449. The suggestion that these would be "rare cases" was not supported by the evidence, which, to the contrary, suggests that the absence of a notch or bulge in military cases is not uncommon. Mr Cox in particular told me that "*Notching at 4kHz is often absent in an audiogram of those exposed to military noise*." That is linked to the second concession namely that in military cases maximum NIHL is often higher than 4 kHz.

450. Professors Moore and Lutman agreed that:

> Observational studies suggest that the frequency of maximum NIHL in military cases tends to be higher than 4 kHz in many cases.

451. The LCB guidelines assume that NIHL is maximal at 4 kHz. As a result, Prof. Lutman had to accept that a slight "qualification" or "adjustment" to the LCB guidelines was required where losses are greatest at 6 kHz. He said in his generic report

> A limitation of this approach is that the adjustment is based on a typical pattern of NIHL, modelled to have a maximum at 4 kHz. Therefore, the

> adjustment factor is less accurately estimated in cases where maximum NIHL occurs at other frequencies. A particular instance is where NIHL is greatest at 6 kHz, as appears to occur in some military cases, in which case the adjustment at 8 kHz would be somewhat underestimated and consequently NIHL would be underestimated. That is not to say that the LCB method is inappropriate for such cases. Rather, the estimate derived from the LCB may need to be qualified and possibly adjusted slightly, depending on the characteristics of the particular case.

452. I received no evidence as to how this qualification or adjustment should be carried out and it is apparent that none was available to practitioners.

453. Mr Green produced reports in each of the 18 Lead and Reserve claims. He applied the LCB guidelines on each occasion, including in Mr Lambie's case. In the course of his oral evidence Prof. Lutman stated, for the first time, that Mr Green should not have applied the LCB guidelines to Mr Lambie's claim. He said:

> I would suggest that the vast majority of the hearing loss that we see in the audiogram in this particular case would be attributed to noise-induced hearing loss. So this would be me deviating from the guidelines, given that they are only guidelines….

454. The central proposition put to Mr Green in cross-examination was that the LCB method is not viable in cases where there was high loss at 8 kHz. Mr Green accepted that the LCB method breaks down and an alternative approach is required in such cases. He then referred to Prof. Lutman's oral evidence that the "Black Book" method could be used, which Mr Green understood to involve subtracting the individual's hearing threshold levels from those of age-associated hearing loss level at the 50^{th} percentile. Mr Green accepted that he was relying on Prof. Lutman's oral evidence because the LCB guidelines themselves were not clear regarding exactly what the alternative approach should be. Mr Green accepted that his practice, in which he did not make an adjustment if the quantification figure already seemed high, meant that he was underestimating the extent of the hearing loss in some cases. His justification was that, although the LCB guidelines refer to these situations, they do not actually set out what should be done.

455. The third concession concerns anchor points. As Mr Steinberg puts it in his written closing submissions:

> The LCB guidelines identify a 'but-for' or comparison percentile based on the anchor points. But the obvious problem with this method is that it cannot be reliable if those anchor points have been affected by noise exposure as often occurs in military NIHL cases.

456. The LCB guidelines provide that "*… there will often be some noise-induced hearing loss at the anchor points, which are usually at the frequencies 1 and 8 kHz*". Those guidelines seek to estimate the extent to which those anchor points have been affected by NIHL by reference to 4 kHz because it "*is the frequency that demonstrates the maximum noise-induced hearing loss*". The guidelines state

that NIHL at the anchor points should be assumed to be a proportion of the NIHL at 4 kHz (assuming 15% of this loss at 1 kHz and 40% at 8 kHz).

457. The problem is, as discussed above, that that is commonly not the position with military NIHL, where there may be no notch or bulge at all and maximal losses are often above 4 kHz.

458. Prof. Lutman acknowledged that this was an additional problem with the application of LCB to military cases when cross-examined by Mr Steinberg:

> *MR STEINBERG: ... It can be quite difficult in these situations because you may have somebody who has been exposed to noise, someone, therefore, who has damage in the anchor points and, therefore, you don't know what their position would have been but for the noise, do you?*
>
> *A. No, you can make some sort of estimation based on their hearing at lower frequencies. So, for example, if their hearing is poorer than average at lower frequencies, it is reasonable to assume that it would probably be poorer than average at other frequencies. Lower frequencies being the ones where noise generally has a lesser effect.*
>
> *Q. This is in addition to the problems which I suggest we have seen with the systematic underestimation where the loss is maximal at 6 kilohertz rather than 4 kilohertz. This is a separate problem. Do you accept that?*
>
> *A. Yes, it is a separate point.*

Discussion

459. In my judgment, Mr Steinberg is right about each of his three points. My conclusion in chapter 7 about the better diagnostic method and the three concessions made by Prof. Lutman lead inevitably to the conclusion that LCB is not a suitable mechanism for quantifying hearing losses in military cases. Military NIHL may not produce a notch or bulge on an audiogram, and it is agreed that the LCB method cannot be applied to cases where there is no notch or bulge. Applying LCB in such a case would lead to an underestimate of NIHL.

460. Furthermore, the Defendant's proposed solution is, in my judgment, wholly inadequate. Prof. Lutman points to Appendix 2 of the LCB guidelines, which suggests than an adjustment can be made at 8 kHz when the threshold at 8 kHz "is clearly out of line". The full passage reads:

> Nonetheless, cases will arise where the threshold at 8 kHz is clearly out of line with the trend for age-associated hearing loss and an alternative approach is required. In such circumstances, it is recommended that the user of the Guidelines should select a threshold value at 8 kHz that is in line with the overall trend for age-associated hearing loss, instead of the measured value, to use in the calculations. That might be achieved by plotting the audiogram against percentile curves for age-associated hearing loss and extrapolating from the thresholds at lower frequencies. While it is recognised that this is somewhat arbitrary and inimical to a formulaic approach, it should only be required in a small minority of cases.

461. The difficulties with that approach are obvious. First, the LCB does not explain what is required to justify a conclusion that the threshold at 8 kHz is "clearly out of line" with the trend. By what degree or amount must the threshold at 8 kHz differ from what is expected for age-associated hearing loss before an alternative approach is necessary? Second, how is the clinician to determine which threshold value to substitute? Third, the appendix suggests as one possible approach "plotting the audiogram against percentile curves for age-associated hearing loss and extrapolating from the thresholds at lower frequencies". What are the alternatives and how is the clinician to decide which is appropriate? Fourth, if in a given cohort, there are a large number of such cases, is this "arbitrary and inimical to a formulaic" approach still appropriate?

462. As Mr Steinberg fairly submits, the guidelines do not explain how this "adjustment" is to be done. Mr Green told me he did not, in practice, make such an adjustment for that reason.

463. It follows that a methodology which in substance depends on a notch or a bulge may fail properly to calculate loss caused by military noise. I certainly do not suggest that the LCB method would fail to produce an accurate calculation in all cases of M-NIHL, but the fact that it will do so in a proportion of cases (notably where 8 kHz is affected) undermines its suitability in such cases. That is particularly so given that military NIHL is often at its greatest at 6 or 8 kHz.

464. The Moore, Cox and Lowe paper avoids these problems. In my judgment, subject to what follows, that approach is to be preferred.

<u>*The Appropriate Percentile*</u>

The Expert Evidence on Percentiles

465. Prof. Lutman advocated tailoring age-related norms closely to the individual's audiogram—an approach consistent with CLB's guidance—and he warned that M-NIHL quantification using fixed percentiles had introduced "rough justice" that risked over- or under-estimating NIHL.

466. Prof. Moore advocated using the 2017/2024 standard 50th percentiles by default as a fair compromise across a population, while allowing percentile adjustments when warranted. He had accepted a degree of rough justice but had argued that consistent rules had promoted equity and reproducibility across claims.

467. The main point of contention for Mr Cox was his choice of percentile. In oral evidence, Mr Cox explained that he prefers to use the 50th percentile, unless he is persuaded otherwise by an individual's medical history. The evidence of a single, poor pre-enlistment military audiogram alone was usually insufficient to depart from the 50th percentile, but he provided a recent example of an individual whose medical history warranted using the 25th percentile instead. Mr Cox made clear that he would not usually choose a better percentile, unless a BSA-compliant audiogram clearly suggests that he ought to do so.

The Competing Cases on Percentiles

468. Prof. Lutman says in the joint report with Prof. Moore that in recent years, "*medical experts have tailored that approach by judiciously choosing a percentile other than the 50th that best seems to match the audiometric evidence*". He says that the LCB guidelines further refine tailoring to the individual "*by adjusting a contour for age-associated hearing loss more precisely to the individual audiogram. Explicit guidance is provided on how to do that. In my opinion, that approach is preferable to the approach of the M-NIHL guidelines*

469. In his 2020 paper, *Diagnosis and quantification of military noise-induced hearing loss* Prof. Moore described his quantification method, including the means for selecting the appropriate percentile:

> M-NIHL can be quantified by comparing the measured HTLs with the thresholds expected from age alone, based on published standards… For quantification of M- NIHL, it is necessary to select an appropriate percentile for the individual concerned. For military personnel, it will often be possible to select the appropriate percentile based on audiograms obtained close to the start of military service. However, occupational audiograms are usually obtained under unknown conditions, and their validity is questionable.
>
> Another possibility is to select the percentile so that the AAHL at 0.5 kHz matches the measured HTL for the ear with the better HTL at **0.5 kHz**. This is based on the assumption that military noise exposure has little effect on the HTL at 0.5 kHz, consistent with the data in Fig. 2. However, there are some problems with this approach. First, military noise exposure can produce NIHL for some individuals at 0.5 kHz. Second, a small error in the measured HTL at 0.5 kHz might result in the choice of an extreme percentile and an inaccurate estimate of AAHL at high frequencies. Also, the audiometric threshold at 0.5 kHz might be affected by noise in the test environment. If occupational audiograms are not available, or are deemed to be too unreliable, then the best approach may be to use the 50th percentile.

470. As Mr Platt observes: "*The original "default position" therefore appears to have been to select the appropriate percentile from the occupational audiometry unless there was a good reason not to do so*."

471. Then in 2022, Prof. Moore produced the MLC paper which included the following:

> In our opinion, the most appropriate method for quantifying M-NIHL is by comparing with the HTLs expected from the 50th percentile of ISO 7029 (2017), as described above. In some cases, it may be appropriate to use a percentile other than the 50th. Reasons for doing this are:
> 1. There are one or more <u>reliable</u> audiograms obtained prior to the start of noise exposure that indicate markedly worse or better hearing than average. If so, the percentile should be based on the pre-exposure audiogram(s).
> 2. A recent audiogram shows HTLs at one or more frequencies that indicate hearing better than the 50th percentile for that individual's age. For example,

if a 47 year old man shows an HTL at 8 kHz of 10dB HL, corresponding to the 65th percentile in ISO 7029 (2017), then it would be appropriate to use the 65th percentile.
3. If one ear has markedly better hearing than the other ear, it is appropriate to base the choice of percentile on the HTLs for the better-hearing ear (emphasis added).

Discussion

472. In order to calculate the extent of hearing loss it is necessary to have a comparison dataset of persons unaffected by NIHL and to identify the percentile in that dataset against which a comparison with the Claimant can properly be made. For the reasons set out in chapter 7, the appropriate database is that used in standard 2017/2024 with baseline correction of 2.4 db at each frequency from 1-8 kHz. It is now necessary to consider the choice of percentile in that data set.

473. Prof. Lutman's position on this issue, as set out above, has been consistent throughout. Prof. Moore's position, by contrast, has varied somewhat over time. In my judgment Mr Platt was right to observe in respect of Moore's 2020 paper that his original *"default position"* was that it was appropriate to select the percentile from the occupational audiometry unless there was a good reason not to do so.

474. Mr Platt was also correct in his submissions in respect of Prof. Moore's 2022 paper. He said first that by "reliable" Prof. Moore means "BSA compliant". It is clear that is what he meant. In cross-examination, Prof. Moore accepted that, in practice, it is "vanishingly rare" for an individual to have a BSA compliant audiogram taken prior to the start of military service, and indeed he had never seen such a case. But for the reason set out in chapter 6 that seems to me too stringent a position. Occupational audiograms should not be discarded and, particularly when part of a series, can provide good evidence of hearing ability. They should be so considered when considering the relevant percentile.

475. Mr Platt also makes a good point when he submits that the scheme advocated by Prof. Moore in MLC is unfairly constructed to favour Claimants. On the one hand, as Mr Platt submits, the likelihood is that in practice, a user of the Moore method would never adjust the percentile downwards and every individual on a percentile below the 50th would thus be overcompensated. But on the other, the percentile might be adjusted upwards (i.e. in favour of the Claimant) by the operation of paragraphs 2 and 3, if an individual shows better than average hearing at only one threshold and, if that threshold is in the better hearing ear, in only one ear. That is plainly unjustified.

476. In my judgment, the proper course is that the choice of the percentile in the relevant dataset should be dictated by the clinical judgment of the medicolegal ENT surgeon based on the hearing profile of the individual as ascertained from all the available audiometry.

The Appropriate Frequencies

The Respective Cases

477. The Claimants invite the following conclusion:

- Quantification should include the binaural average of 1, 2, and 4 kHz and should not be confined to the binaural average of 1, 2, and 3 kHz**.**

478. The Defendant invites the Court to conclude:

- Overall hearing disability should ordinarily be calculated by reference to the average hearing thresholds over 1, 2 and 3 kHz.

The Evidence

479. In their joint report Professors Moore and Lutman say that in a medicolegal context, it has been conventional in the UK to assess hearing disability using the average of hearing thresholds at 1, 2 and 3 kHz, although for a period the BSA favoured the 1-2-4-kHz average. In a medicolegal context in the United States, the 0.5-1-2-3-kHz average is most commonly used. In some other countries, such as Australia, the average includes 4 kHz. The World Health Organization uses the 0.5-1-2-4-kHz average to assess hearing disability.

480. Professors Moore and Lutman agree that NIHL may be approximately predicted from increments in binaural hearing threshold level. They agree that individuals generally do not perceive gradual changes of less than 4–5 dB and that difficulties in speech-in-noise perception occur even in persons without noise exposure (a condition called King–Kopetzky Syndrome or Obscure Auditory Dysfunction).

481. Prof. Lutman says that there is no disagreement between him and Prof. Moore "*that 4 kHz is a good predictor of speech recognition in noise*" but he says it "*is not materially better than any frequency between 2 and 6 kHz. Thresholds at those frequencies are highly correlated with one another, so it is unsurprising that they have similar correlation with speech recognition scores.*" He says that "*the conventional approach of using the binaural 1- 2-3-kHz average to assess hearing disability is very well established and there are tables available to assess quantum on that basis. Changing to a different metric would require new tables. In my opinion, that would not lead to any practical benefit".*

482. Prof. Lutman maintains that the long-established binaural 1–2–3 kHz average is the correct and conventional metric for assessing hearing disability. He emphasises that it is supported by well-recognised quantification tables and widespread medico-legal practice. His work in the case of *Hunt v India Mills* concluded that thresholds at 4 and 6 kHz did not add statistically significant predictive value once thresholds at 1, 2, and 3 kHz and age were taken into account. He explains that thresholds across 2–6 kHz are highly correlated with each other and with age, meaning their predictive behaviour is substantially overlapping. He says that shifting to a different metric would necessitate new quantification tables without producing any material benefit for disability assessment.

483. Prof. Moore contends that the 4 kHz threshold should be afforded significant weight as an independent predictor of NIHL He states that Prof. Lutman's approach is biased by the conventional selection of the 1–2–3 kHz frequencies and contends that an unbiased analysis would begin with the frequency that independently offers the strongest predictive capacity—typically, he contends, 4 kHz. In support, he refers to studies such as Smoorenburg (1992) and Kryter et al. (1962), which, in his view, demonstrate that 4 kHz consistently emerges as a significant predictor when analysed without pre-selection of frequency bands. Prof. Moore places weight on modern communication standards, including high-definition telephony involving frequencies up to 8 kHz, which he contends supports the functional relevance of frequencies beyond 3.4 kHz.

484. He criticises the simulations relied upon by Prof. Lutman for not modelling cochlear synaptopathy or neuropathy—conditions which, he argues, contribute to deficits in speech-in-noise perception associated with NIHL. He therefore rejects the suggestion that the simulations provide a basis for restricting assessment to the 1–2–3 kHz average. He also highlights broader support for the 0.5–1–2–4 kHz average as a universal metric of hearing status, citing recent academic research and standards adopted by international bodies including the American National Standards Institute.

485. The two ENT experts recognised that there is a range of opinion on this issue. In their joint report, they remarked that many experts use the "Black Book" guidance, which advocates the use of 1/2/3 kHz. (The Black Book referred to is: 'Guidelines for Medicolegal Practice: Assessment of Hearing Disability' by P.F. King, R.R.A. Coles, A.P. Lutman, A.C. Davis, D.W. Robinson.) However, they also drew attention to a caveat in the Black Book guidance to the effect that individuals with hearing losses outside this range may still have a hearing disability.

486. Mr Cox supported the use of 1/2/4 kHz. His reasons in his section of the joint report were twofold. The first concerns current practice. He identified the use of 4 kHz in the Coles Worgan classification of auditory handicap, used by some in the UK in respect of noise-induced hearing loss. He referred to the use of 4 kHz in assessments of disability throughout the UK by the NHS, the Republic of Ireland, Australia, and the World Health Organization.

487. His second reason concerns the role of 4 kHz in understanding speech. It was his view that hearing at frequencies above 3 kHz is important in understanding speech in everyday levels of background noise. He relied on evidence from Prof. Lutman himself in the 2008 paper "Health and Safety Executive: Epidemiological evidence for the effectiveness of the noise at work regulations", ("the Health and Safety Executive 2008 paper"). In his oral evidence during the Primer session, Mr Cox explained the reasons for the connection between high-frequency loss and understanding certain consonants in noise in the same way as Prof. Moore.

488. Conversely, Mr Green supported the use of 1/2/3 kHz. He provided three reasons in his section of the joint report. The first also concerns current practice. He asserted that hearing disability is conventionally assessed over 1/2/3 kHz in the UK as well as in the USA (where 0.5 kHz is also included). Secondly, he said that low frequencies are most important for speech in quiet environments, and

satisfactory communication by telephone occurs in the bandwidth between 0.3 and 3.4 kHz. Thirdly, he said that there is insufficient evidence to demonstrate that hearing loss above 3 kHz is significant.

The Competing Arguments

489. Mr Platt, for the Defendant, maintains that the long-established convention of averaging hearing thresholds at 1, 2 and 3 kHz remains both scientifically defensible and practically reliable. He places substantial emphasis on the results seen in the Lead Cases and the settled cases, noting that: 'the calculated binaural hearing loss is essentially indistinguishable whether one averages 1, 2 and 3 kHz or 1, 2 and 4 kHz' (as demonstrated, for example, in Mr Lambie's case where the difference was only 0.06 dB). He submits that this pattern of negligible differences—ranging only from –0.6 dB to +2.2 dB—shows that the conventional approach cannot be said to misrepresent disability.

490. In support of this, Mr Platt refers to Harris (1960), who emphasised that "hearing at 3 kHz should be included into an index of hearing handicap instead of the loss at 0.5 kHz'. He further cites Kryter et al. (1962), who, despite acknowledging that 'the three most important test frequencies ... would be 2000, 3000 and 4000 cps', nonetheless recommended that 'the use of losses at 1000, 2000 and 3000 cps would be a reasonable compromise ... and gives essentially as high a multiple correlation' as the higher-frequency combination.

491. He also relies upon Anianson (1974), whose speech-discrimination research indicated that subjects with 'normal hearing up to and including 3000 Hz ... scored 28–43% less than normal' when loss began at 3000 Hz, whereas those with loss only at 4000 Hz 'scored 8–16% less' and 'no significant differences were found between the normal and [the] L4000 group' in certain listening situations. According to Mr Platt, this supports the thesis that intact hearing through 3 kHz is functionally decisive, and that loss at 4 kHz has more limited real-world consequence.

492. Mr Platt places considerable reliance on the 1992 'Black Book' Working Group. He draws attention to the Group's conclusion that the scientific evidence was 'insufficient ... on its own to compel a decision on the frequency combination' and that practical matters, including the unreliability of 0.5 kHz and the risk that a 4 kHz notch 'may be quite deep (20 dB or more)' could lead to 'inflated HTL measurement' not reflective of the underlying audiogram, justified retaining the 1, 2, 3 kHz average.

493. He addresses Smoorenburg (1992) by emphasising that, although the author found that the ability to hear speech in noise was best predicted by metrics including 4 kHz, the 'difference in coefficients for 1, 2, 3 and 4 kHz ... were not significant' and, crucially, Smoorenburg 'did not consider the frequency combination 1, 2 and 4 kHz' at all. Dobie (2012), he argues, reinforces this point: the study found that 'none (of the combinations tested) were significantly better than the AMA method ... namely the pure-tone average over 0.5, 1, 2 and 3 kHz', and that 4 kHz was among the 'weakest' single predictors of communication performance.

494. By contrast, Mr Steinberg, for the Claimants, contends that the question is not binary and that the Court should recognise the functional importance of 4 kHz to everyday hearing. He notes that 'experts for both sides ... give estimates based on both 1, 2, 3 kHz and 1, 2, 4 kHz' and that the Claimants' ENT expert Mr Cox, for example, routinely includes 4 kHz in his clinical assessments outside litigation.

495. Central to Mr Steinberg's submission is the research of Smoorenburg (1992). He notes that Smoorenburg found the 'ability to hear in a noisy environment was best predicted by averaging the loss over 2 and 4 kHz' and that the combination 2, 3 and 4 kHz performed nearly as well; and although differences among 3, 4 and 6 kHz were statistically small, they consistently favoured the inclusion of 4 kHz. He also emphasises that Prof. Moore's 2016 review concluded: 'There is very strong evidence that NIHL for frequencies above 3 kHz has adverse effects on the ability to understand speech, especially when background noise is present', and that audiometric thresholds at 4 kHz 'should be taken into account when considering compensation' for NIHL.

496. Mr Steinberg also revisits the Black Book, observing that its authors expressly stated that their chosen compromise 'should not be construed as implying the absence of any disability' where losses occur outside the 1–3 kHz range. He submits that improvements in audiometric testing and the centrality of speech-in-noise difficulties in this litigation justify giving weight to 4 kHz today. He highlights that in *Hunt v India Mills*, Professors Moore and Lutman agreed that speech recognition in noise correlates best with 'pure-tone thresholds across a frequency range from 2 to 8 kHz ... with the highest correlation coefficients between 3 and 5 kHz', with 4 kHz giving the maximum coefficient 'by a margin of approximately 0.02'.

Discussion

497. The central dispute between the experts concerns the methodological foundation for determining which frequencies properly reflect disability arising from NIHL. Prof. Lutman emphasises convention, statistical correlation across frequencies, and the absence of demonstrable incremental predictive value when using 4–6 kHz thresholds after accounting for age and 1–2–3 kHz thresholds. Prof. Moore emphasises independent predictive value at 4 kHz, the inadequacy of simulations that omit cochlear synaptopathy, and wider developments in scientific and technological standards.

498. It is apparent that the dispute between the parties centres not on substantial numerical differences, these are consistently shown to be modest, but upon the functional significance of high-frequency hearing loss, particularly as it relates to speech perception in noise. On the evidence I have seen, it is clear that the traditional 1, 2, 3 kHz average remains a reliable, if conservative, measure of hearing disability, supported by longstanding practice and by parts of the literature that continue to recognise its adequacy. At the same time, the scientific material relied upon by the Claimants, notably Smoorenburg and Moore, suggest that frequencies above 3 kHz, and 4 kHz in particular, play an important role in the perception of speech in noisy environments, sound localisation, and recognition of environmental sounds.

499. I conclude that, while the conventional 1, 2, 3 kHz average should continue to serve as a baseline descriptor, it is entirely legitimate to consider 1, 2 and 4 kHz, particularly where speech-in-noise difficulty is a prominent feature of a Claimant's disability. It should be for the ENT expert to identify which metric best represents the Claimant's disability. The modest numerical differences do not undermine the utility of either approach; rather, they indicate that both metrics should potentially be available to the Court, with the weight to be attached to each depending on the factual and audiometric circumstances of the individual Claimant.

Asymmetry

500. This issue turns on the question whether NIHL should always be quantified by the use of a binaural average figure, in other words a value that combines hearing from both ears to provide a single representative figure.

The Competing Cases

501. The Claimants invite the Court to conclude that

- Where there is asymmetrical hearing loss, calculating the binaural NIHL on a 4 to 1 ratio in favour of the better ear may not accurately reflect a Claimant's hearing disability.

502. The Defendant invites the Court to conclude that:

- NIHL ought only to be quantified when the ear in question has been diagnosed with NIHL, whether because it meets the diagnostic threshold or because it is possible to make a bilateral diagnosis based on Note 11 of CLB.

The Evidence

503. Mr Cox and Mr Green agreed that in military noise damage, significant hearing asymmetry is common, if not the norm. In some cases, a small binaural estimate can significantly underrepresent the damage to hearing of the individual

504. In his oral evidence, Prof. Moore described his personal experience as a result of suddenly losing hearing entirely in one ear:

> I very quickly discovered that I was much worse at understanding speech in noise, and I was much worse in echoey rooms. I was much more affected by the echo in the rooms, because we use binaural hearing to suppress echoes in rooms and I lost that ability. So, certainly one remaining ear can partially compensate, but not entirely. There is still a considerable deficit from a hearing loss in one ear….
> There is another specifically binaural effect where we can actually compare the detailed timing of the signals at the two ears and use that information to pick out a sound we want to hear from background sounds. That ability to process interaural time is reduced with hearing impairment and is reduced even more when the impairment is asymmetric, when one

> ear has worse hearing than the other ear. Then you get a deficit in the ability to process this binaural information, which leads to greater difficulty in the cocktail party situation.

505. The "cocktail party situation" describes the difficulty of hearing individuals where there are many speakers in close proximity.

506. Prof. Moore explained in oral evidence that hearing aids provided limited assistance with difficulties hearing speech in noise:

> One aspect of hearing disability is a loss of ability to hear soft sounds. Now, that can make it difficult even to understand speech when there is not any background noise. Hearing aids are very effective in restoring audibility, making sounds audible, so hearing aids overcome, to a large extent, problems in understanding soft speech in quiet situations. The disability after using hearing aids is in understanding speech in noisy situations.

507. Prof. Moore co-authored a paper in 2023 which considered the issue. In summary, he found that hearing aids help, but they by no means restore hearing to "normal". It is fair to say, as Mr Steinberg submits, that was reflected by the experience of Mr Lambie both with his old hearing aids and his newly purchased set.

508. In his oral evidence concerning Mr Craggs, Mr Green also explained that a binaural calculation should not be used to determine the need for a hearing aid, as the heavy weighting of the calculation in favour the better ear could indicate that no aiding was required when, in fact, a significant loss in one ear did warrant the use of a hearing aid.

509. Mr Green also accepted that when there is significant asymmetry in hearing loss, with loss in one ear but no loss in the other ear, then a 4:1 calculation in favour of the better ear does not always accurately represent an individual's disability. The following extract comes from his cross-examination:

> *Q. Is it wrong to do the 4 to 1 ratio then in that case?*
> *A. I think there are cases where you can have a significant excess loss in the worse hearing ear and no excess loss in the good hearing ear, where the calculation of 4 to 1 doesn't necessarily capture the problems that you are having.*
> *MR JUSTICE GARNHAM: Is that not the reason -- is that not because of the*
> *reason why you take four of the best and one of the worst? Namely, that the brain compensates when it has one good hearing ear?*
> *A. Yes, I agree with that, my Lord. The idea is that the better ear -- the idea of that calculation, which I think is used, certainly universally amongst experts within the UK, that is the calculation 4:1. I think, in the States, it is 5:1.*
> *MR JUSTICE GARNHAM: Which makes the point even stronger.*
> *A. Yes. So I think in those cases, if, say, you had an excess loss in the worse ear but not in the better ear, then you have to -- there has to be a recognition that maybe the excess loss doesn't maybe reflect the overall problems the person is having, and you may need to look at other things,*

like do they have other symptoms; do they need a hearing aid; has it affected their employment? So I don't think it is the case that excess loss always, particularly in these cases, captures all of the problems that an individual may be having.

Competing Submissions

510. Relying on this evidence, Mr Steinberg submitted that the evidential basis for the use of a 4:1 ratio in favour of the better ear is limited. He says that the authors of the Black Book in 1992 accepted that the experimental data was scanty. Nonetheless he acknowledges that the authors considered the previous suggestion of 4:1 was reasonable even if it was based on "conjecture without any experimental foundation".

511. Prof. Moore maintains that quantification should proceed bilaterally even where one ear fails to meet the diagnostic threshold. The Defendant submits that such an approach is illogical and results in inflated and unrealistic assessments of binaural disability, particularly where the better-hearing ear has not been diagnosed with NIHL.

512. Mr Platt relies upon the research of Anianson, which he said demonstrates that individuals with unilateral hearing loss usually perform better in speech-in-noise tests than those with bilateral loss of an equivalent magnitude. This evidence undermines the suggestion that the better ear may properly be treated as impaired when no diagnosis exists. Instead, the research supports a diagnosis-led and conservative approach to quantification.

513. Mr Platt argued that the central issue for determination is whether quantification of NIHL may be applied to both ears irrespective of whether each ear meets the established diagnostic threshold. He said there was no rational basis upon which a high probability of NIHL may be assumed in an ear that fails to meet diagnostic criteria. The criticism is especially pertinent where the alleged exposure was asymmetrical. In such cases, the assumption that the less-exposed or non-exposed ear has sustained NIHL is unsustainable.

514. As to the study conducted by Keim involving thirteen individuals exposed to rifle fire without hearing protection, the Defendant does not dispute that such exposure may lead to asymmetrical hearing loss. However, it is submitted that the study cannot properly be relied upon to support Prof Moore's proposition that NIHL may be quantified in a non-diagnosed ear. The absence of threshold data at 8 kHz deprives the study of the necessary diagnostic comparability and renders verification of criteria impossible.

515. Mr Platt further argues that Prof Moore's approach adopts a generic model that fails to consider the specific factual basis of each Claimant's exposure. He says that in circumstances where unilateral exposure is alleged, Moore's bilateral quantification method is conceptually flawed and inconsistent with the evidence. He argues that the practical consequences of Moore's approach are demonstrated in the case of Mr Craggs. There, the right ear did not meet the diagnostic criteria for NIHL. Nevertheless, Prof. Moore attributed 5 dB of NIHL to that ear and 8.3 dB to the left ear. This increased the binaural hearing loss calculation from 1.7 dB

to 5.66 dB (if the left ear had 8.3 dB of NIHL). The Defendant contends that this increase was artificial and flowed solely from the improper attribution of NIHL to an ear not diagnosed with the condition.

516. Conventional binaural disability calculations weight the better ear four times more than the poorer ear. The Defendant submits that Moore's method—by assigning even minimal NIHL to a non-diagnosed better ear—distorts the disability figure significantly and inconsistently with established audiological principles.

517. For these reasons, Mr Platt submits that NIHL should only be quantified in an ear that either meets the diagnostic criteria or may properly be included within a bilateral diagnosis under Note 11 of CLB. Any wider approach lacks evidential foundation, is methodologically unsound, and produces unreliable assessments of disability.

Discussion

518. Mr Steinberg does not dispute the fact that the 4:1 calculation has long been used in this country and abroad. In my judgment, in the majority of cases, that is a sensible and reasonable approach, reflecting that widespread clinical practice and the fact, as Mr Green explained in evidence, that where an individual has good hearing in one ear but poor hearing in the other the brain, to some extent at least, compensates.

519. Mr Steinberg is critical of the 4:1 calculation but does not propose an alternative. The evidence he has adduced enables the making of general observations about potential limitations of the formula but does not establish a basis for an alternative approach.

520. The evidence I heard demonstrates that there are cases where the excess loss calculation does not fully reflect the totality of the problems experienced by the Claimant. In such case there needs to be a clinical judgment in the light of those symptoms as to whether, for example, hearing aids or better hearing aids are needed. An expert preparing a report for a Court in such a situation should explain why, on the particular facts of the case, it is necessary to consider a different approach. On such facts, the Court assessing damages would need to consider whether the binaural calculation adequately reflects the full extent of the disability.

Conclusions on Quantification

521. In my judgment, the Moore, Cox and Lowe method of quantification is to be preferred.

522. The choice of the percentile in the relevant dataset should be dictated by the clinical judgement of the medicolegal ENT surgeon based on the hearing of the individual ascertained from all the available audiometry.

523. As to the appropriate frequencies to consider, the conventional 1, 2, 3 kHz average should continue to serve as a baseline descriptor. However, it is entirely

legitimate to consider supplementary metrics that incorporate 4 kHz, particularly where speech-in-noise difficulty is a prominent feature.

524. As to asymmetric assessment, NIHL should generally be quantified using the 4:1binaurial calculation. But where it is thought the excess loss calculation does not fully reflect the totality of the problems experienced by the Claimant, the clinician and ultimately the Court needs to identify, assess and reflect the additional disability.

Chapter 10 – Latency and Acceleration

525. In this chapter I address the question whether military noise exposure can accelerate deterioration of hearing after exposure has ceased, and, if so, the parameters of any such effect.

526. I propose taking this issue rather shortly; even when a Court is considering generic issues relevant to a substantial cohort of cases, it does not engage in pure scientific debate unconnected to real issues of fact or law which it is in a position to determine on the facts of individual cases.

The Competing Contentions

527. The Claimants submit that:

- Impulsive military noise exposure can advance or accelerate later hearing threshold level change even where, at the end of the period of exposure, there is no hearing loss or such hearing loss is mild.
- Damage to the cochlear reserve explains how sub-clinical damage, which may or may not be visible on an audiogram, is later unmasked by age, producing earlier onset/faster change in the audiogram than age alone and leaving a Claimant worse off than they would have been.
- Where the hearing threshold at relevant frequencies at the end of exposure is less than 50–55 dB, acceleration/advancement is plausible but, above that level, there will be no accelerative change and perhaps even a decrease in the rate of change.
- The specific characteristics of military noise (very high peaks, impulses that can bypass acoustic reflexes, complex spectra) materially increase later vulnerability.
- The practical effect and implications of these findings must be considered on a case-by-case basis on the evidence in an individual case.

528. The Defendant invites the Court to conclude as follows:

- The theory that hearing loss may continue to develop after exposure has ceased is no more than a hypothesis. The epidemiological and study evidence is weak and/or contradictory. It has not yet reached scientific maturity and therefore must be viewed as "unproven". On this generic issue, the orthodox view that hearing loss does not progress after exposure ceases should prevail.
- Even if the acceleration theory was sufficiently plausible as to be viewed as "probable" more than "possible", it cannot properly be applied to the circumstances of any given case or individual. The facts in *Craggs* clearly illustrate this impossibility. Hence individual causation fails *in limine*.
- Even if the theory is demonstrable and a mechanism can be conceived whereby it could be identified in a given individual, there is no way in which accelerated loss can be accurately quantified in such a fashion as to make a secure foundation for any award of damages.

The Issue

529. The conventional view, for many years, has been that damage caused by exposure to noise ceases when the noise ceases. Prof. Moore told me that "10 to 15 years ago the consensus view would be that exposure to noise did not accelerate the subsequent progression of hearing loss, but since that time new evidence has appeared…".

530. The evidence of that in humans, however, is very thin indeed.

531. Prof. Moore has proposed a theory that noise may cause sub-clinical or latent damage which becomes clinically significant, or patent, as a result of subsequent developments, most obviously aging. The mechanism postulated for this process is that noise causes damage to cochlear hair cells but there is a surfeit of hair cells so that the loss of a small number has no clinical consequence. However, once the surfeit, or reserve, is used up, further loss of hair cells caused for example by aging, has a clinical effect.

532. Prof. Lutman, by contrast, upheld the orthodox position that NIHL develops during exposure but does not progress thereafter. He urged caution about extrapolating from animal studies with narrowband, anaesthetised exposures and large temporary threshold shifts.

533. Both Prof. Moore and Prof. Lutman referred to paper published in 2025 in the Journal of the American Medical Association Otolaryngology by Dillard LK, Humes LE, Matthews LJ, and Dubno JR, "Noise exposure history and age-related changes to hearing". The paper describes a large-scale longitudinal study of hearing, and documents change in hearing over an interval averaging 5 years. Both experts regarded this work as of significance. After allowing for baseline age, sex and race, data were analysed according to a 3-point historic self-reported noise exposure rating. A key finding was that those rated as having high noise exposure showed more rapid deterioration in hearing (compared with lower noise exposure or no noise exposure) at the audiometric frequencies of 1 and 2 kHz. The reverse was shown for the audiometric frequencies of 3-8 kHz. It is not clear whether participants continued to be exposed to noise during the study period.

534. In his report, Prof. Plack describes the 'cochlear reserve' mechanism as plausible. In his oral evidence, he stated that he broadly agreed with Prof. Moore on the issue, although he expressed some doubt about the conclusion drawn by Prof. Moore on the studies on acceleration in military personnel. Prof. Plack agreed with my suggestion that the consequence of the 'cochlear reserve' mechanism is not that hearing loss is accelerated, but rather that the start of hearing loss is advanced.

535. Prof. King concurred. In his formulation, the advancement could be characterised as "adding a certain number of years to one's ears".

The Competing Arguments

536. Mr Steinberg contended that there exists a scientifically recognisable phenomenon whereby AAHL progresses more rapidly in individuals previously exposed to hazardous noise, even where contemporaneous audiometry at the time

of service discharge does not demonstrate significant impairment. This acceleration, he submitted, arises from underlying cochlear pathology not immediately detectable on audiometric testing but which manifests itself in later life.

537. He relied heavily upon the expert evidence of Prof. Moore, whose thesis is that mild or even absent noise-induced hearing loss at discharge can nonetheless potentiate a subsequently accelerated rate of deterioration, quantified in his publications at up to 1.7 dB per annum in certain frequency ranges. Mr Steinberg submitted that this evidence represents a developing scientific consensus, supported by Moore's own longitudinal work and the study of Dillard.

538. He argued that the criticisms advanced by the Defendant and its experts fail to displace the Claimants' case. In particular, he submitted that (i) the absence of a fully elucidated biological mechanism does not prevent the Court from accepting an observed phenomenological effect; (ii) the existing human studies do not contradict the acceleration thesis but are either neutral, underpowered, or limited in methodological design; and (iii) the existence of individual variability in hearing trajectories does not preclude a finding of generic causation.

539. Mr Steinberg contended that the Defendant's reliance upon what it termed the "orthodox view"—that noise-induced hearing loss ceases to progress once exposure ends—fails to recognise the changes in contemporary scientific literature. He submitted that the Defendant's stance largely reflects historic policy assumptions, not modern empirical findings.

540. He submitted that the case of Craggs, which the Defendant had characterised as demonstrating the impossibility of identifying acceleration, instead illustrates the very phenomenon in dispute: namely, the appearance of deterioration only years after service. He rejected the Defendant's characterisation of Prof. Moore's approach in that case as inconsistent or self-serving.

541. Throughout his submissions, Mr Steinberg sought to emphasise that the Court need not require scientific certainty but rather sufficient evidential foundation to conclude, on the balance of probabilities, that military noise exposure materially contributed to a subsequently accelerated rate of hearing decline. He submitted that, when the expert evidence is viewed as a whole, such a conclusion is justified.

542. Mr Platt argues that the so-called latency or acceleration theory lacks scientific maturity, is unsupported by convincing epidemiological data, and has not been accepted within orthodox audiological science. He says that the conventional position remains that any NIHL occurs contemporaneously with exposure, ceasing when the exposure ceases. The latency theory is not only unproven but founded upon speculative mechanisms which even its proponent cannot identify. The evidence, it is submitted, is inconsistent, contradictory, and fails to displace established orthodoxy.

543. Even if one assumes, for argument's sake, that the latency/acceleration hypothesis is scientifically plausible, Mr Platt says it cannot rationally be applied to any individual case. The illustration relied upon is the case of Craggs. There, a Claimant with no deterioration in hearing during service, and no reliable evidence of accelerated decline thereafter, was nonetheless said by Prof. Moore to be

suffering latent acceleration which had simply not yet manifested. The Defendant asserts that it is impossible to test that theory and that it is therefore of no probative value. The theory's application is so elastic and unbounded that it permits success for any Claimant irrespective of temporal sequence or audiometric evidence, thereby creating what he called a "heads I win, tails you lose" paradigm.

544. Mr Platt further emphasises the absence of any coherent biological mechanism capable of explaining how NIHL could progress years after exposure has concluded. He says that Prof. Moore, under questioning, accepted that he could not identify the underlying process. The Defendant contends that his approach involves reasoning backwards: adopting the existence of acceleration as a premise, and then attempting to retrofit a speculative biological account to support it. Alternative mechanisms suggested in evidence—including synaptopathy, stria vascularis impairment, and acoustic reflex phenomena—were said to be unproven, contradicted by relevant studies, or not reflective of human hearing physiology as presently understood. The Defendant submits that without a plausible physiological basis, the theory cannot satisfy the threshold of scientific reliability required for generic causation.

545. The Defendant further submits that animal studies do not support the Claimants' case. While certain experimental research has shown synaptic injury or neural loss after extreme, often non-physiological noise exposures in mice or other animals, these conditions cannot be extrapolated to human occupational noise. The Defendant argues that such laboratory work operates at intensity levels, durations, and biological contexts not applicable to military service or comparable environments, and cannot therefore support an inference of latent damage or long-term AAHL acceleration in humans. Mr Platt also criticises reliance on the concept of cochlear reserve—a theoretical concept positing that early noise exposure may reduce the ear's future capacity to tolerate age-related decline—on the basis that there is no direct human evidence for its operation, and that even on its own terms it would predict only a short advancement of AAHL onset, not an ongoing acceleration decades later.

546. Ultimately, Mr Platt concludes that the Claimants have failed to discharge the burden of proof in establishing either the existence of an acceleration mechanism at a generic level, or its application in individual cases. The Defendant submits that the evidence is insufficient, controversial, immature, or contradictory, and that the correct medical and legal conclusion is that NIHL does not progress after noise exposure ceases. He urges the Court to prefer the orthodox, additive model, and to reject the latency/acceleration hypothesis as unproven, unworkable, and incapable of forming the basis for any award of damages.

Discussion

547. It has been widely believed for decades that damage from noise does not affect the subsequent progression of hearing loss with increasing age. More recently, that view has been challenged. Studies using mice have shown that exposure to intense (100 dB SPL) one-octave wide noise for 2 hours, sufficient to cause temporary threshold shift (TTS) of 35-50 dB, measured 24 hours after exposure, led to greater hearing loss at old age than for non-exposed controls. Reducing the noise level to 91 dB SPL eliminated that effect.

548. These animal studies demonstrate that noise exposure can cause substantial loss of mainly outer hair cells without causing measurable hearing loss. Those findings suggest that in the animals tested there is a "cochlear reserve"; in other words that there is a surplus of hair cells which can be damaged without noticeable effect. That notion has led to the suggestion that prior noise exposure (without measurable hearing loss) could hasten the onset of age-associated hearing loss, leading to greater age-associated hearing loss in noise-exposed individuals than in non-exposed controls. The idea is that the earlier noise exposure reduces the quantity of hair cells so that further loss, as would be expected from aging, more quickly causes the total quantity to drop below the critical level at which point hearing loss becomes clinically significant and hearing acuity is reduced. It follows that development of noise-induced hearing loss could be delayed relative to the onset of noise exposure.

549. Performing corresponding studies in primates is challenging in view of their much longer lifespan. Experimental studies in humans are neither justifiable nor practicable. Therefore, observational studies in humans provide the only way to address this issue for humans. There are a small number of observational studies available, but Prof. Lutman and Moore disagree regarding their interpretation.

550. I share Mr Platt's scepticism about the reliance placed by the Claimants on those studies. I agree that the best-designed longitudinal human studies—Lee (2005), Hederstierna (2016), and Macrae (1971)—provide no support for acceleration. These studies show no difference in the rate of hearing decline between noise-exposed individuals and matched controls. That supports the orthodox view that AAHL and NIHL are additive, not multiplicative. In my judgment, Prof. Moore's attempts to reinterpret, or as Mr Platt puts it "to rewire" Macrae (1971), including by substituting modern ISO standards for contemporaneous age-matched populations, are methodologically unsound and lead to comparisons of "apples and pears".

551. By contrast, in my view, the small cohort study by Moore & Lowe (2022), the principal empirical basis for his 1.7 dB/year acceleration hypothesis, is unreliable; it is too small to be convincing and is self-selecting and unrepresentative. It lacked an adequate control group and provided no robust inferential foundation.

552. However, I reject Mr Platt's argument that the theory that hearing loss may continue to develop after exposure has ceased is entirely implausible. In my view it is intellectually coherent and gains some support from the studies in mice. Further scientific studies may yet prove the theory sound in primates and even, conceivably, applicable to human beings. But in my judgment, we are some considerable distance from that as yet. On this generic issue, the orthodox view that hearing loss does not progress after exposure ceases has not yet been displaced.

553. I am reinforced in this view by the fact that, as the Defendant contends, the latency/acceleration theory has not been recognised by any authoritative body. National and international scientific institutions, including the UK government, the Industrial Injuries Advisory Council, the United States government, and the international ISO standard-setting process, continue to adopt the orthodox view that NIHL occurs at the time of, or very soon after, the exposure.

554. I also agree with Mr Platt that even if the acceleration theory was sufficiently plausible as to be viewed as "probable", which in my view it certainly is not at present, it cannot properly be applied to the circumstances of any given case or individual. Furthermore, Mr Platt is right that even if the theory is demonstrable and a mechanism can be conceived whereby it could be identified in a given individual, there is no way in which accelerated loss can be accurately quantified in such a fashion as to make a secure foundation for any award of damages.

555. In those circumstances, it is my conclusion that the theory that hearing loss may continue to develop after exposure is plausible, intellectually coherent but a very long way from being proven in human beings. The orthodox view that hearing loss does not progress after exposure ceases has not, at least at yet, been displaced.

556. Further, and more fundamentally, there is at present no conceivable mechanism by which the effect of this alleged phenomenon could be identified or quantified in any individual Claimant.

Chapter 11 – Cochlear Synaptopathy

557. In this chapter I address the topic of cochlear synaptopathy. The expression "cochlear synaptopathy" refers to a loss in the connections ('synapses') between inner hair cells in the cochlea, the part of the ear which detects sounds, and the auditory nerve fibres, which carry the signals from the inner hair cells to the brain. The relevance of this issue to this litigation is that such synaptopathy might lead to individuals experiencing hearing difficulties (sometimes referred to as 'hidden' hearing loss), even if they have audiometric thresholds within the normal range.

The Competing Cases

558. The Claimants invite the Court to conclude that:

- Cochlear synaptopathy is now a recognised noise and age-related cochlear pathology, distinct from outer hair cell loss and threshold shift.
- Where military noise has been sufficient to cause permanent threshold elevation, it is likely to have also caused synaptopathy.
- On the basis of current medical science, a definitive diagnosis of synaptopathy in humans is not currently possible during life.
- The Court should proceed cautiously, on a balance of probabilities, by triangulating noise exposure, the overall clinical picture and the broader scientific picture.
- While individual quantification is uncertain, cochlear synaptopathy in the context of military noise, is both plausible and a potential contributor to speech-in-noise difficulty and tinnitus, and should be weighed accordingly.

559. The Defendant invites the Court to find that the evidence on cochlear synaptopathy, while interesting, ultimately does not add anything to the lead cases (or, indeed, the wider cohort) for several reasons:

- First, while there is consensus between the experts that cochlear synaptopathy occurs in all species, it cannot be definitively demonstrated, let alone quantified, in humans before death.
- Second, although various 'proxy measures' of cochlear synaptopathy in humans have been mooted and investigated, the evidence for them is very mixed. There are no norms, and no gold standard test. In any event, none of the lead cases has undergone any of these proxy measures.
- Third, cochlear synaptopathy occurs with ageing in humans and there is no established and validated means of trying to strip out 'synaptopathy of ageing' in any of the lead cases, even if they were to undergo the above-mentioned proxy measures.
- Fourth, the extent to which noise exposure causes cochlear synaptopathy in humans is uncertain. The only relevant postmortem study, the Dias paper, showed only a 'modest effect' of noise on cochlear synaptopathy, compared with age. In general, studies trying to find correlations between noise exposure and proxy measures of synaptopathy are very mixed or negative.
- Fifth, it appears that humans may be able to suffer up to 90%+ deafferentation prior to there being any symptomatic effect (*Liu*). There is therefore no synapse-survival-to-symptom relationship except at what appears to be the

extremes. There is no study that validates this level of destruction in military or civilian personnel as a result of noise exposure.

- Sixth, while studies on military personnel show a somewhat clearer trend picture with respect to cochlear synaptopathy, they are far from conclusive and have no application to the circumstances of an individual. They certainly do not establish that some, all or most military personnel will probably suffer cochlear synaptopathy.
- Seventh, accepting the premise of noise-related cochlear synaptopathy in some military personnel, the evidence does not establish that this will make any practical difference to hearing ability, either (i) in the presence of audiometric hearing loss or (ii) without measurable audiometric hearing loss.

560. Thus, the Defendant argues, for none of the lead Claimants (or anyone in the wider cohort), can noise- induced cochlear synaptopathy be (i) definitively demonstrated, (ii) persuasively demonstrated by proxy measures, (iii) quantified, (iv) disentangled from age-related synaptopathy, or (v) connected to any particular adverse effect. In short: (a) the oral evidence ultimately did not move things beyond the agreed joint statement of the experts, Profs. Plack and King, which both experts were content to adopt in their oral evidence; (b) cochlear synaptopathy is, in this litigation at least, a dead end.

The Evidence

561. Prof. King was instructed by the Claimants. He is a Wellcome Principal Research Fellow and Professor of Neurophysiology and the Director of the Centre for Integrative Neuroscience in the Department of Physiology, Anatomy and Genetics at the University of Oxford. The Defendant instructed Prof. Plack. He is the Ellis Llwyd Jones Professor of Audiology at the University of Manchester and, since writing his report, has become Emeritus Professor of Auditory Neuroscience at Lancaster University. Both were experts of the highest distinction.

562. Prof. King told me that cochlear synaptopathy was first identified in 2009 in studies conducted by researchers in Boston, Massachusetts. It is distinct from the traditional mechanism of noise-induced hearing loss, which has historically focused on deterioration of outer hair cells. Prof. King explained in his oral evidence that synaptopathy can occur even where standard clinical audiograms register normal thresholds. This is because synaptopathy affects those auditory nerve fibres responsible for transmitting suprathreshold information, especially in challenging acoustic environments.

563. There was much common ground between the two experts. Indeed, their joint statement recorded no substantive areas of disagreement.

564. Professors King and Plack agreed that it is likely that some degree of synaptopathy may arise from the high levels of noise exposure that can be experienced during military service, particularly if adequate hearing protection is not worn properly. This view is based on considerable evidence from animal studies. However, extreme noise levels often experienced in military settings can also cause other forms of inner ear pathology, which makes a selective diagnosis of cochlear synaptopathy all the more challenging.

565. They explained that the problem is that there is no gold standard diagnostic measure for synaptopathy in humans. The only definitive method is a post-mortem histological examination of the cochlea carried out in individuals with a documented history of noise exposure. Only one such post-mortem study exists, namely the study by Pei-Zhe Wu et al., "*Primary Neural Degeneration in Noise-Exposed Human Cochleas: Correlations with Outer Hair Cell Loss and Word-Discrimination Scores*", 2021 ("the Wu 2021 study"). The abstract to that paper is as follows:

> Animal studies suggest that cochlear nerve degeneration precedes sensory cell degeneration in both noise-induced hearing loss (NIHL) and age-related hearing loss (ARHL), producing a hearing impairment that is not reflected in audiometric thresh- olds. Here, we investigated the histopathology of human ARHL and NIHL by comparing loss of auditory nerve fibers (ANFs), cochlear hair cells and the stria vascularis in a group of 52 cases with noise-exposure history against an age-matched control group. Although strial atrophy increased with age, there was no effect of noise history. Outer hair cell (OHC) loss also increased with age throughout the cochlea but was unaffected by noise history in the low-frequency region (,2kHz), while greatly exacerbated at high frequencies (22kHz). Inner hair cell (IHC) loss was primarily seen at high frequencies but was unaffected by noise at either low or high frequencies. <u>ANF loss was substantial at all cochlear frequencies and was exacerbated by noise throughout.</u> According to a multivariable regression model, this loss of neural channels contributes to poor word discrimination among those with similar audiometric threshold losses. The histopathological patterns observed also suggest that, whereas the low-frequency OHC loss may be an unavoidable consequence of aging, the high-frequency loss, which produces the classic down-sloping audiogram of ARHL, may be partially because of avoidable ear abuse, even among those without a documented history of acoustic overexposure (emphasis added).

566. As can be seen, that study revealed a statistically greater loss of auditory nerve fibres in the noise history group than in an age-matched control group. However, the effects were modest (much less than the effects of age) and the noise history group included far fewer females than the control group. Synaptopathy is also said to occur with increasing age, and therefore may be a contributory factor to age-related hearing disorders.

567. In oral evidence, Prof. King suggested that the Wu 2021 study might have underestimated the loss of synapses because they had to examine the loss of auditory nerve fibres, which occurs subsequent to the loss of synapses. Prof. Plack's main reservation in respect of the Wu 2021 study was that other factors, such as smoking history and body mass index, may well have contributed to the hearing loss, but were not taken into account when matching the noise-exposed group with the control group. In addition, Prof. Plack pointed out that it was unknown what treatment these individuals had received prior to their death, which may also have affected the loss of synapses.

568. Given the difficulties with post-mortem examination, many studies in human beings have instead looked for less direct indicators, or proxies, of cochlear synaptopathy in the form of behavioural or physiological measures of auditory

function similar to those that have been shown in animal studies. These measures are the auditory brainstem response wave 1, compound action potential 1, middle ear muscle reflex, and envelope following response. The experts agreed in their joint report that in the studies of military personnel, there are more consistent changes in these measures compared to studies of those exposed to recreational or occupational noise, where the evidence for the predicted change in these proxy measures is very mixed. In oral evidence, Prof. Plack stressed that all these proxy measures are affected by factors other than synaptopathy, and so it is very challenging to disentangle the effects of synaptopathy.

569. In the studies of military personnel, there are more consistent changes in these measures compared to studies of those exposed to recreational or occupational noise. A recent important study involving over 10,000 military service members is Brungart et al., "*Not-so-normal hearing: Temporary hearing changes lead to chronic difficulties for listeners with "normal" audiometric thresholds*", 2025 ("the Brungart 2025 study"). It found that the degree of self-reported hearing difficulty was associated with noise exposure, even within the "normal" range of audiometric thresholds, and the results were consistent with synaptopathy. However, the two experts observed that no objective measures of cochlear function were included and there was no histological evidence.

570. In oral evidence, Prof. King explained that synaptopathy suggests an additional way in which information from the ears to the brain could be lost by affecting, for example, temporal processing (i.e. the ability to follow signals rapidly changing over time) and the ability to understand speech signals in the presence of background noise.

571. Prof. King said that one of the strengths of the Brungart 2025 study is its size, although Prof. Plack added the caveat that, in studies of this size, even small changes are then more likely to be statistically significant. Prof. Plack mentioned this point in the context of his primary criticism, namely that the Brungart 2025 study relied on self-reported data. Prof. Plack had two further criticisms: firstly, that only data from the better ear (and not the worse ear) was presented, and secondly, that there were measurements only up to 4 kilohertz (rather than up to 6 and 8 kilohertz). On the latter criticism, Prof. King commented that a scope of up to 4 kilohertz adhered to the standard definitions of "normal" hearing.

572. Without post-mortem cochlear histology, it is also currently not possible to conclude in relation to human beings that tinnitus or any impairments in hearing ability are necessarily due to synaptopathy. Nevertheless, the two experts agreed that subclinical noise damage (damage that is not revealed by audiometric hearing thresholds) may be a cause of tinnitus. Furthermore, animal studies have shown that such damage (particularly loss of auditory nerve fibres) can induce changes in central auditory processing that could contribute to listening difficulties.

573. Prof. King was taken to Liu et al., "*Quantifying the Impact of Auditory Deafferentation on Speech Perception*", 2024 ("the Liu 2024 study"). It found that speech perception thresholds in noise increased significantly only after there was more than 90% of deafferentation (loss of auditory nerve fibres from the cochlea to the brain as a result of synaptopathy). Prof. Plack suggested that, based on the modelling of the Liu 2024 study, the figure should be more than 50% (rather than 90%).

574. Prof. King was cautious about that figure as the Liu 2024 study did not take into account the effects of synapse loss on the brain. In his view, the brain would compound the effects of synapse loss due to the way in which the coding of sounds within the brain works.

575. I was also referred to a later Bramhall paper, Bramhall and McMillan, "*Perceptual Consequences of Cochlear Deafferentation in Humans*", 2024, the abstract of which reads as follows:

> Cochlear synaptopathy, a form of cochlear deafferentation, has been demonstrated in a number of animal species, including non-human primates. Both age and noise exposure contribute to synaptopathy in animal models, indicating that it may be a common type of auditory dysfunction in humans. Temporal bone and auditory physiological data suggest that age and occupational/ military noise exposure also lead to synaptopathy in humans. The predicted perceptual consequences of synaptopathy include tinnitus, hyperacusis, and difficulty with speech-in-noise perception. However, confirming the perceptual impacts of this form of cochlear deafferentation presents a particular challenge because synaptopathy can only be confirmed through post-mortem temporal bone analysis and auditory perception is difficult to evaluate in animals. Animal data suggest that deafferentation leads to increased central gain, signs of tinnitus and abnormal loudness perception, and deficits in temporal processing and signal-in-noise detection. If equivalent changes occur in humans following deafferentation, this would be expected to increase the likelihood of developing tinnitus, hyperacusis, and difficulty with speech-in-noise perception. Physiological data from humans is consistent with the hypothesis that deafferentation is associated with increased central gain and a greater likelihood of tinnitus perception, while human data on the relationship between deafferentation and hyperacusis is extremely limited. Many human studies have investigated the relationship between physiological correlates of deafferentation and difficulty with speech-in-noise perception, with mixed findings. A non-linear relationship between deafferentation and speech perception may have contributed to the mixed results. When differences in sample characteristics and study measurements are considered, the findings may be more consistent (emphasis added)

576. In his oral evidence, Prof. Plack told me that if individuals have hearing loss exhibited on an audiogram, there is a good chance that they have synaptopathy. He said the evidence for synaptopathy causing tinnitus was stronger than for listening effort and difficulty in discriminating speech in noise. He disagreed with the conclusion of the 2024 Bramhall paper that, although the relationship between the proxy measures and speech perceptions were not consistent across all the studies that they reviewed, studies using certain proxy measures and/or testing old populations or military personnel tended to find that weaker physiological measurements were associated with poorer speech perception performance. Prof. Plack's fundamental criticism was that their data referred overwhelmingly to the effect of age rather than noise.

577. I also heard evidence on this subject from Professors Moore and Lutman.

578. Prof. Moore had pointed to accumulating human evidence that reduced neural output (deafferentation) had been associated with speech-in-noise deficits, particularly among older adults and noise-exposed populations, and he had argued that very mild audiometric losses could still have been accompanied by meaningful communication disability.

579. Prof. Moore said in his generic report that there was evidence that synaptopathy increases the likelihood of tinnitus.

580. He referred in particular to a study specifically concerned with military veterans which was conducted by Bramhall et al in 2023. That report noted that:

> several physiological measures are sensitive to synaptopathy, including the auditory brainstem response (ABR), the middle ear muscle reflex (MEMR) (GL), and the envelope following response (EFR). They studied human participants with normal audiograms who were grouped according to Veteran status and tinnitus report…The estimates of MEMR and EFR magnitude were lower for Veterans with tinnitus than for non-Veterans, with the most evident reduction for the EFR. The magnitude of the Veteran tinnitus effect on the EFR was compared to age-related reductions in EFR magnitude and synapse numbers observed in previous studies.

581. Prof. Moore said that these analyses suggested that EFR magnitude/synapse counts were reduced in veterans with tinnitus by roughly the same amount as is produced by over 20 years of aging. Bramhall concluded that cochlear synaptopathy <u>may</u> contribute to tinnitus perception in noise-exposed veterans.

582. Prof. Lutman had cautioned that there had been no established clinical methodology for diagnosing cochlear synaptopathy or neuropathy in humans and that animal models had not mapped cleanly onto real-world exposures. He had emphasised the need for robust norms that had controlled for audiometric loss and age before any medico-legal application.

583. While Lutman and Moore both acknowledged uncertainty in this area, they differed on how much weight the Court should place on what it was suggested were “emerging findings".

<u>*The Competing Arguments*</u>

584. Mr Steinberg submitted that cochlear synaptopathy represents a significant and scientifically recognised form of auditory injury arising both from excessive noise exposure and from ageing. He contended that the Defendant’s treatment of this pathology betrays a fundamental misunderstanding of both the underlying scientific literature and the particular nature of military noise-induced hearing loss.

585. Prof. King and Plack agreed that where noise exposure is sufficient to produce measurable degradation in hearing thresholds, it is likely also to have produced synaptopathy. The Claimants’ ENT experts agreed with this analysis and stated that, on the balance of probabilities, several of the lead Claimants, including Mr Lambie and Mr Craggs, had developed synaptopathy.

586. Mr Steinberg’s case emphasised the extreme levels of noise to which military personnel are routinely exposed. The evidence from acoustic engineers showed

that peak sound levels from weapons, including rifles and machine guns, can reach between 145 and 175 dB. Such levels far exceed the intensities known to induce synaptopathy in animal models. Prof. King explained that animal studies deliberately titrate noise exposure to produce selective synaptic injury. When scaled to human equivalents, military noise clearly meets or exceeds these exposure levels.

587. Similarly, continuous noise exposure in armoured vehicles can reach 113 to 119 dB(A), levels which correlate with significant risk of synaptic loss. The Claimants submitted that the Defendant's suggestion that animal study exposures were unrealistically high ignored the evidence that military exposures are, by any standard, extreme.

588. Mr Steinberg highlighted the limitations inherent in human histological research: the inner ear cannot be biopsied during life. However, post-mortem studies, particularly Wu et al (2021), demonstrated greater auditory nerve fibre loss in noise-exposed individuals, including veterans. These studies likely underestimate synaptic loss because synapses degrade earlier and faster than nerve fibres.

589. In addition, human studies using proxy physiological measures such as auditory brainstem response, "envelope-following" response, and compound action potential have shown reductions in young military personnel with normal audiograms. Large-scale studies by Brungart et al (2025) and Grant et al (2021) demonstrated that service members frequently report hearing difficulties, especially in noisy environments, despite having normal audiometric thresholds. Mr Steinberg argued that synaptopathy offers the most compelling explanation for this disconnect. These studies show strong correlations between noise exposure and functional auditory deficits independent of threshold elevation.

590. Synaptopathy impairs the ability to perceive speech in noise, produces tinnitus, and can lead to hyperacusis. Bramhall and McMillan (2024) showed that synaptopathy preferentially affects low-spontaneous-rate auditory nerve fibres, which are essential for coding suprathreshold sounds in noise. Thirteen of eighteen studies reviewed found statistically significant relationships between reduced physiological indicators of synaptopathy and speech-in-noise difficulties in high-risk groups such as older adults and noise-exposed military personnel.

591. Mr Steinberg submitted that the Defendant's assertion that references to synaptopathy were "redundant" stemmed from a failure to appreciate that military NIHL is characteristically distinct from occupational noise exposure. The consensus among the experts was that synaptopathy is a likely and important component of the Claimants' hearing difficulties. On the balance of probabilities, the majority of the Claimants have developed cochlear synaptopathy.

592. Mr Steinberg therefore invited the Court to conclude that cochlear synaptopathy is a real and scientifically grounded consequence of extreme military noise exposure; that it is likely present in the Claimants; and that it offers a coherent explanation for their symptoms beyond that offered by standard audiometry.

593. Mr Platt's central submission in response was that cochlear synaptopathy cannot be demonstrated, diagnosed, quantified, or causally attributed to noise exposure in any living individual, including the Claimants, with the result that the concept can play no legitimate evidential role in these proceedings.

594. First, he emphasised the agreed expert evidence that cochlear synaptopathy can only be definitively identified and quantified by post-mortem histological examination of the cochlea. Because pre-mortem examination is impossible (owing to the anatomical inaccessibility of the inner ear within the temporal bone, and because imaging lacks the necessary spatial resolution), no Claimant can establish the existence or extent of synaptopathy during life. On that basis alone, he submitted, the concept is incapable of satisfying the requirements of proof in individual claims.

595. Second, Mr Platt relied upon the consensus that no "gold-standard" non-invasive diagnostic method exists for identifying synaptopathy in living humans. The experts described the evidence from human studies as inconsistent, heterogeneous, and insufficient to permit firm conclusions. Longitudinal baseline data, necessary for meaningful comparison, are unavailable, including for all the Claimants. Even if a Claimant were tested, the absence of reference ranges and the large degree of variability would make results uninterpretable.

596. Third, he noted the experts' agreement that, in the absence of direct methods, researchers have used a range of "proxy measures", (including those referred to by Mr Steinberg), to infer possible synaptopathy. These tests originate in animal studies and have not been validated in humans. Mr Platt stressed that the experts agreed that such measures are imprecise, affected by multiple confounding factors unrelated to synaptopathy, and characterised by substantial variability. There are no population norms against which results can be interpreted, and the experts accepted that none of the proxy measures can diagnose or quantify synapse loss in an individual. He also highlighted evidence that some measures may not reflect cochlear processes at all, being influenced by central auditory pathways or age-related changes.

597. Fourth, he submitted that age-related cochlear synaptopathy is well-established in the scientific literature, and was acknowledged by the experts. He pointed to evidence (such as the Wu et al. post-mortem data) showing substantial age-related synaptic loss in individuals over 50, and observed that all the lead Claimants are of an age when deterioration would be expected. Because no reliable method exists to separate age-related from noise-related synapse loss, and because age effects are substantially larger than any postulated noise effect, causation cannot be established, even in principle.

598. Fifth, he drew attention to the joint expert evidence that the scientific case for noise-induced cochlear synaptopathy in humans remains unproven. The only post-mortem study attempting to examine noise effects (Wu et al., 2021) identified only modest reductions in auditory nerve fibres in noise-exposed subjects, and suffered from limitations in group matching. Proxy-measure studies in military and other noise-exposed populations showed at most small, inconsistent effects, often confounded by factors such as sex, audiometric thresholds, and psychological or cognitive influences. He made particular reference to the experts' joint statement and to literature (including Bramhall, Oxenham, Liu and others) concluding that evidence for noise-induced synaptopathy in humans is equivocal or weak, and that synaptic losses of far greater magnitude than those observed would be required to produce measurable functional deficits.

599. Finally, he submitted that the perceptual consequences alleged by Claimants, such as speech-in-noise difficulty or tinnitus, cannot be reliably attributed to synaptopathy. The experts accepted that these perceptual differences do not correlate robustly with proxy measures or with any presumed synaptic loss, and are influenced by a variety of non-auditory factors. In many cases, he argued, conventional outer hair cell damage provides a well-established alternative explanation.

Discussion

600. I accept that the balance of the expert evidence establishes that cochlear synaptopathy is a distinct pathology, at least in animals and likely in humans. But I also accept, as the Claimants concede, that on the current state of medical knowledge, it is not possible to make a definitive diagnosis of synaptopathy in humans in life. It is certainly conceivable that where noise has been sufficient to cause permanent threshold elevation, it may also cause synaptopathy. But in my judgment, it is not possible to go further.

601. The Claimants invite me to say that, by a process of "triangulation" with noise exposure, the individual's clinical picture and "the broader scientific picture" a Court could conclude that synaptopathy is a potential contributor to speech-in-noise difficulty and tinnitus. In my judgment, that amounts to an invitation to speculate, both as to the applicability of animal studies to humans and as to potential causative effect of the condition. It is an invitation I decline, because neither of those matters are established on the evidence.

602. I accept the broad thrust of the Defendant's objections to this proposition. It is common ground that cochlear synaptopathy can only be identified and quantified post-mortem. I accept Mr Platt's submission that the results of human studies are insufficiently certain to permit firm conclusions; the proxy measures discussed are imprecise and variable in their results, and do not exclude other potential causes for the results produced, most obviously age. As Mr Platt points out, the Wu post-mortem data shows substantial age-related synaptic loss in individuals over 50 and there is no reliable method to separate out age-related synaptopathy from noise-related synapse loss, so causation cannot on the present evidence be proven.

603. I find particularly compelling the concluding paragraph from a 2019 paper by Bramhall et al, "*The search for noise-induced cochlear synaptopathy in humans: Mission impossible?",* of which Prof. Plack was a co-author and to which both he and Prof. King referred:

> Despite a concerted international research effort over the past several years, conclusive evidence for noise-induced cochlear synaptopathy in humans remains elusive. In this commentary, we have discussed some of the possible reasons behind this. We have described how each of the various experimental approaches, including electrophysiological, questionnaire and behavioural measures have proved to be imperfect metrics. Although there may be techniques we can use to control variability, improve robustness, and increase statistical power, we seem far from reaching a satisfactory diagnostic approach.
> There are also <u>important questions to be answered about the extent to which human synaptopathy mirrors the animal models, particularly in relation</u>

> to the intensity of noise that is needed to induce synaptic damage in humans, the relative susceptibility of low-, medium- and high-SR fibers, and the possibility that structural repair at the synapse may occur following early auditory insults. Given that aging and cumulative noise exposure are necessarily correlated and associated with peripheral and central damage in addition to synaptopathy, disentangling noise-induced synaptopathy from deterioration of other auditory structures may prove to be an insurmountable challenge.
> Nevertheless, it is important to continue our efforts to determine whether synaptopathy occurs in humans, and to better understand its potential perceptual effects. As one of several peripheral and central factors that may contribute to suprathreshold hearing deficits in humans, we need to be able to characterize its relative influence on an individual's overall auditory function. Understanding these relationships is essential if we are to move beyond the audiogram towards a holistic model of person-specific hearing care that diagnoses and treats both the "hidden" and "unhidden" components that underlie human hearing impairment (emphasis added).

604. It does not seem to me that any of the later "efforts", or papers, to which I have been referred have answered the questions posed in the latter part of that passage.

605. In conclusion, in my view the Defendant is correct when they submit that cochlear synaptopathy cannot definitively be demonstrated, let alone quantified, in humans before death. 'Proxy measures' of cochlear synaptopathy are less than certain and there is no gold standard test for the condition. Studies on military personnel suggest noise may lead to cochlear synaptopathy but there is no certainty of that and these studies have no application to the circumstances of individual Claimants. In any event, cochlear synaptopathy occurs with ageing in humans and there is no mechanism for stripping out 'synaptopathy of ageing' from 'synaptopathy of noise exposure' or of establishing that noise exposure made an identifiable difference to hearing ability either in the presence of audiometric hearing loss or in its absence.

Chapter 12 - Tinnitus

606. The issue to be addressed in this chapter is whether tinnitus which begins at a date significantly later than the cessation of exposure to the relevant noise can be attributed to it.

607. The Claimants invite the Court to conclude that:

- Tinnitus may be attributed to military noise exposure despite the absence of any elevation of audiometric hearing thresholds.
- Tinnitus may still be attributed to military noise exposure when the onset of the condition occurs after the noise exposure has ceased.
- Clinical judgment must be exercised in each individual case, but noise-induced tinnitus can probably arise years after the cessation of noise exposure.

608. The Defendant invites the Court to conclude that:

- Temporal causation is highly relevant to any decision as to whether tinnitus which becomes symptomatic at a time distinct from the original exposure to noise is caused by it.
- In the absence of any secure scientific evidence of such a connection, tinnitus which begins more than one year or so after cessation of noise exposure cannot, on a balance of probabilities, be attributed to it.

The Evidence

609. In Appendix 5 to his generic report, Prof. Lutman said that at face value, onset of tinnitus after a long delay makes causal connection implausible. He said that the nature of scientific evidence that would be required to support the proposition that noise exposure could cause tinnitus some years later makes proving the proposition almost impossible. He acknowledged that there is some evidence from animal studies, notably in a paper by JJ Eggermont, that the onset of tinnitus may be delayed following damage, but the delay there he said was only of the order of a few days.

610. He pointed to a report from the US Department of Veterans Affairs entitled "*Noise and Military Service: Implications for Hearing Loss and Tinnitus*" which concluded that there was lack of evidence to support the notion of delayed onset hearing loss or tinnitus, and to one from the Department of Health and Children in Ireland which stated

> Noise induced permanent tinnitus should start at or about the time of exposure to noise (i.e. within 1 year of the cessation of exposure). Tinnitus that starts more than 1 year after the removal from a noisy environment is unlikely to be related to noise. In view of the high prevalence of tinnitus in normal populations, tinnitus due to age related hearing loss and tinnitus of unknown origins should be considered as possible causes of the tinnitus.

611. The UK Department of Work and Pensions publication on Occupational Deafness (1992), states that: "*Tinnitus is a common symptom in the adult population occurring at some time in about 30% of adults and increasing in prevalence with*

age. Noise is a common cause of tinnitus, but it can result from other causes. Tinnitus which starts more than a year after exposure to noise has ceased is unlikely to be due to noise".

612. Prof. Lutman acknowledged the contrary view expressed by Professor Coles in his chapter in Scott-Brown's Otolaryngology.

> Prof. Coles suggests that hearing loss is the major factor causing tinnitus and whatever caused the hearing loss probably caused the tinnitus.
> The triggering factor is the combination of hearing loss from whatever causes. Applying this rationale to Claimants, said Prof. Coles, would suggest that the aggregation of the effects of noise and age-associated hearing loss reaches a tipping point sufficient to initiate tinnitus. The age-associated hearing loss would have accrued over the period following noise exposure until it eventually triggered the tinnitus. Without the noise-induced hearing loss, the aggregate hearing loss would have been lower and the tinnitus may not have occurred.

613. However, according to Prof. Lutman, this opinion of Prof. Coles is merely speculation and is not supported by specific evidence. Carried to the extreme, the argument would mean that anyone who had accrued hearing loss due to noise exposure, however slight, and then experienced tinnitus much later, could attribute the tinnitus to noise exposure.

614. Prof. Lutman said that it was important to recognise that tinnitus is very common in the general population (see "*Prevalence and characteristics of tinnitus in older adults*": the Blue Mountains Hearing Study. International Journal of Audiology 2003; 42: 289- 294.) and that the majority of people with tinnitus will have not been exposed to hazardous noise and not have any noise-induced hearing loss. In the vast majority of cases the aetiology of the tinnitus is unknown. Therefore, there is a substantial incidence of spontaneous onset of troublesome tinnitus in the general population, unrelated to noise exposure.

615. Prof. Lutman concluded that where tinnitus had commenced long after noise exposure had ceased, a causative link had not been established to the balance-of-probabilities standard.

616. However, on questioning, Prof. Lutman accepted that onset of tinnitus occurring "the day after" loud noise would justify a conclusion that the exposure caused the tinnitus, that he had no "fixed maximum gap"; that 6–12 months might be a guideline but was not definitive; and that individual circumstances must be examined case by case.

617. In his joint report with Prof. Lutman, Prof. Moore offered the opinion that "*it is more likely than not that tinnitus emerging after noise exposure has ceased was caused at least partly by the noise exposure*". He referred to the opinion of Prof. Coles in "The Tinnitus Handbook" (Singular, Thompson Learning, pp. 399-318 at page 403) that "*if the cause of the hearing loss is a cumulation of noise-induced and age related disorders, then it is probable that tinnitus coming on years after a period of noise exposure has ceased is due to that cumulated disorder, that is, noise damage as well as the age-related degeneration* ". He said Prof. Coles was

"*widely regarded as a leading expert on tinnitus with over 20 publications related to tinnitus*".

618. As set out in the previous chapter, Prof. Moore was also of the view that cochlear synaptopathy may contribute to tinnitus perception in noise-exposed military personnel. He said that that delayed-onset tinnitus had been plausibly linked to earlier noise damage in many cases and that years could have elapsed between exposure and symptom onset.

619. The ENT experts agreed on a number of basic issues. In their joint report, they acknowledged that tinnitus is a purely subjective symptom that no objective test can identify. Accordingly, diagnosis of tinnitus, which depends entirely on an individual's history of symptoms, must be determined in each case on its individual merits. If there is a positive diagnosis, then hearing aids, tinnitus sound therapy, and tinnitus counselling are the main management strategies, which have variable outcomes between individuals.

620. Mr Green and Mr Cox also recognised that tinnitus can occur in individuals with normal hearing as well as individuals with hearing loss. Where the individual has hearing loss, the cause of the hearing loss will generally be the cause of tinnitus too, although the underlying cause of the tinnitus cannot always be known. Where the individual has normal hearing, exposure to very loud noise still creates a material risk of tinnitus. In the Judicial Primer, they observed that tinnitus is reported to occur in up to 15% of individuals, and the percentage of individuals with tinnitus progressively increases with age.

621. The key point of disagreement between the ENT experts concerned delayed onset tinnitus. They agreed that the starting point was that delayed onset tinnitus is possible. The dispute centred on the length of the delay after the cessation of noise exposure, at which the onset of tinnitus can still be attributed to the noise exposure. It was agreed that any view on delayed onset tinnitus is ultimately based on opinion because it can neither be proven nor disproven by objective evidence.

622. Mr Cox's position was that tinnitus can occur decades after the cessation of noise exposure. In his section of the joint report, he criticised the statement in the DWP 1992 report that "[t]innitus which starts more than a year after exposure to noise has ceased is unlikely to be due to noise". He argued that that report was flawed for three reasons. First, it was based on a semi-random sample, which was not defined. Second, the DWP focused on individuals primarily experiencing vibration, and so those with tinnitus symptoms but without vibration would have been screened out from the sample. Third, only those with tinnitus starting within a year of the cessation of noise exposure were recorded, and not those with tinnitus starting more than a year after cessation of noise exposure.

623. In cross-examination, Mr Cox was asked to identify what evidence he relied upon for his view that tinnitus starting decades later is possible. He referred to a 1992 study by Axelsson and Barrenäs, "*Tinnitus in Noise-Induced Hearing Loss*", ("the Axelsson 1992 study"), but accepted that the Axelsson 1992 study might not in fact support his view because it concerned individuals in continuous employment and did not specify when the noise exposure ceased.

624. Mr Cox then cited Prof. Coles' opinion as the basis of his own view (the same opinion of Prof. Coles with which Prof. Lutman had disagreed). Mr Cox accepted, however, that Prof. Coles' view was ultimately no more than an expression of opinion because it is impossible to obtain evidence to support or negate an opinion regarding tinnitus.

625. Mr Green's general view, in his section of the joint report, was that the longer the time between the cessation of alleged noise exposure and the onset of tinnitus, the greater the likelihood that another factor has caused or contributed to symptoms of tinnitus. In cross-examination, he accepted the proposition that there was potentially a four-year delay in the onset of tinnitus caused by noise exposure in the case of Mr Davies, although he was cautious about whether the noise exposure had indeed ceased at the time as alleged. This led him to express his opinion more generally that, in contrast to Prof Lutman, he would not necessarily impose a 12 or 18-month cut-off period for delayed onset tinnitus. He reiterated that his approach would be to look at each case individually.

Competing Arguments

626. For the Claimants, Mr Steinberg submits that the Defendant's experts, Mr Green and Prof. Lutman, have already conceded key elements of the issue, namely that noise is a recognised cause of tinnitus and that tinnitus may present without concurrent audiometric hearing loss. He therefore submits that the question devolves to causation in individual cases rather than to exclusion as a matter of principle.

627. Referring to the academic literature, he argued that tinnitus symptoms may reflect subclinical cochlear damage despite normal audiograms (Guest et al (2017)); that noise exposure can induce tinnitus without permanent threshold shift (Lewis et al (2020)); and that tinnitus may signal pathological auditory injury not revealed by conventional audiometry (Theodoroff et al (2020)).

628. He accepts that tinnitus occurs in the general population, but submits that it is relatively uncommon, particularly in younger adults. Mr Steinberg stresses the importance of how prevalence questions were framed. Studies reporting very high figures often failed to distinguish transient from permanent tinnitus or used very broad questions. When restricted to prolonged spontaneous tinnitus, prevalence drops significantly, often to around 10%. This is illustrated by the UK National Study of Hearing and the table discussed by Sindhusake et al (2003).

629. Several studies with higher figures (e.g., Sataloff; Rosenhall & Karlsson; Sindhusake) involved predominantly older age groups (55+ to 90). These cannot be extrapolated to the predominantly younger military cohort. Moreover, even in such older groups, methodological breadth (inclusion of any tinnitus of any duration) inflates prevalence and reduces relevance to clinical attribution.

630. Studies of spontaneous tinnitus in noise-unexposed adults (Axelsson & Ringdahl; Coles; Quaranta; Walsh & Clark) consistently show rates between 10% and 14.5%. These data support Mr Steinberg's argument that idiopathic tinnitus is uncommon in healthy younger adults, making noise exposure a more plausible cause in military Claimants.

631. Noise-exposed worker groups have consistently high rates of tinnitus. For example, 49.8% in the study by Chung et al and McShane et al. Tinnitus prevalence is also elevated in compensation Claimants and hearing clinic populations. These findings support the proposition that noise exposure dramatically increases tinnitus risk.

632. Mr Steinberg emphasises that tinnitus is "very common" among military personnel: veterans are twice as likely as non-veterans to have tinnitus (Theodoroff, 2020); 33% of service members and 44% of recently separated veterans report constant tinnitus, despite clinically normal hearing (Henry et al, 2019); 48% of young veterans (19–35) with normal hearing reported frequent or constant tinnitus (Bramhall et al, 2018); 76 of 80 military noise-exposed participants reported tinnitus (Moore et al 2021); up to 80% of noise-exposed naval personnel may develop chronic tinnitus (Yankaskas 2013); 42.5% of Finnish army officers with NIHL reported tinnitus (Ylikoski et al 1994):.

633. He also emphasised that the distinct characteristics of military impulsive noise are known to produce higher tinnitus rates than continuous industrial noise. Axelsson et al (1992) observed tinnitus in 63–70% of impulsive-noise-exposed populations, as against 47–57% in continuous-noise groups.

634. Central to Mr Steinberg's submissions is that tinnitus arising years after noise exposure can still be caused by that exposure. He pointed to Mr Cox's opinion that tinnitus onset may occur after noise cessation because of the combined effect of earlier noise damage and subsequent changes including age-related hearing loss. He draws explicitly on Prof. Coles' view, set out in the Tinnitus Handbook in 2000, that tinnitus coming on years later may represent the cumulative effect of noise and age-related degeneration. Prof. Coles says that noise-induced tinnitus does not always arise during exposure; it may appear considerably later.

635. Mr Steinberg makes sound forensic points about Prof. Lutman's change of mind during the course of his evidence; initially Prof. Lutman had asserted that tinnitus commencing after cessation of noise exposure cannot safely be attributed to noise, but later he agreed that onset after a day or 6 months or 1 year might be possible. He also points to the fact that Mr Green stated in oral evidence that he "*wouldn't necessarily cut* (the link between noise exposure and tinnitus) *off at 12 or 18 months*", and that he considers each case individually. In a similar vein, Mr Steinberg points out that in the lead claim of Mr Davies, the Defendant accepted causation despite a potential four-year delay between cessation of noise exposure and onset of tinnitus. That, he argues, directly contradicts the Defendant's proposed generic finding.

636. Mr Steinberg observes that the Defendant relies on administrative reports from the Irish Department of Health in 1998 and the UK DWP in 2002 suggesting tinnitus should arise within a year of exposure. Mr Steinberg argues these documents contradict Prof. Lutman's early stance; acknowledge delayed onset in practice; and represent policy tools for benefit assessment, not scientific or clinical causation analysis. He submits that they carry little weight compared to authoritative clinical literature and expert evidence.

637. Mr Steinberg submits that the totality of evidence—scientific, clinical, epidemiological and expert—demonstrates that:

- Noise exposure is a well-recognised cause of tinnitus.
- Tinnitus can be caused by noise even without measurable NIHL.
- Tinnitus is rare in the general population, especially among young adults, but extremely common in noise-exposed and military groups.
- Impulsive military noise presents a distinctively high tinnitus risk.
- Delayed-onset tinnitus is clinically recognised, scientifically supported, and accepted in practice, even by the Defendant's experts.
- Causation is a matter of individual assessment, not a rigid temporal rule.

638. He therefore invites the Court to answer the generic question in the affirmative: tinnitus arising after cessation of military noise exposure can properly be attributed to that exposure, subject to evaluation of the evidence in each case.

639. In response, Mr Platt submits that the central question for determination is whether tinnitus can properly be attributed to military noise exposure where the onset of symptoms occurs long after the cessation of that exposure. The Defendant's position is that temporal causation is highly significant, and absent reliable scientific evidence to support delayed-onset noise-induced tinnitus, tinnitus emerging more than roughly one year after cessation of exposure cannot, on the balance of probabilities, be attributed to noise.

640. Mr Platt submits that there are neither diagnostic criteria nor scientific evidence establishing that noise exposure can cause tinnitus appearing years after such exposure. He relies on evidence from Messrs Green and Cox stating that no evidence proves or disproves delayed-onset tinnitus and that any view to the contrary is opinion.

641. Mr Platt relies on the opinion of Prof. Lutman that tinnitus is common and often spontaneous; and that late-onset causation is scientifically unverifiable. He characterises Prof. Moore's evidence as unbalanced, reliant on the opinions of others, and providing no mechanism for causal apportionment. He says that Mr Cox's evidence was significantly undermined in cross-examination. His reliance on an Axelsson study was shown to be based on misinterpretation and he ultimately accepted that his position rested only on the unsupported opinion of the late Prof. Coles.

642. Mr Platt says that the US Veterans Affairs department, the Irish Department of Health, and UK Department for Work and Pensions all conclude that tinnitus beginning more than a year after exposure is unlikely to be noise-related.

643. Using the Andrew Davies case, Mr Platt argues that inconsistencies in onset history and ongoing noise exposure demonstrate that the Claimants' attribution analysis is unreliable.

644. Mr Platt contends that the scientific literature and expert consensus support the conclusion that tinnitus arising more than one year after exposure is unlikely to be noise-induced; that the Claimants' expert evidence lacks scientific foundation; and that the evidence of Prof. Lutman and Mr Green should be preferred.

Discussion

645. Tinnitus is the perception of sound in the head that does not have a source outside the body. It can be either objective or subjective. The former, where the sound is audible to the examiner, is rare. Its objective nature makes diagnosis and estimates of date of onset relatively straightforward.

646. It is the latter with which I am concerned. Its subjective nature, the fact that it can only be heard by the person who reports it, means it cannot be proven or measured or assessed except on the basis of the sufferer's experience. Determining the timing of its onset, its intensity and duration are all dependant on report of the sufferer. But it is nonetheless very real and can be the source of considerable distress. Its subjective quality, however, makes it impossible to prove its cause, or to date its onset, scientifically, and very difficult to determine forensically.

647. There are conflicting expert opinions on the issue I have to address as to whether tinnitus which begins at a date significantly later than the cessation of exposure to the relevant noise can be attributed to it. But however eminent are the sources of those opinions, they are never more than opinions; none of them have been proven by scientific method. Whether viewed from the standpoint of individual Claimants, or a cohort of Claimants, they have to be tested against such evidence as there is.

648. That evidence seems to me to fall into four categories of which the first and fourth are the most important for the present issue. First and foremost is the evidence of the person reporting tinnitus. No doubt, most who complain of tinnitus report honestly the symptoms from which they suffer. But no Court determining a damages claim can make any such assumption in the case of a particular Claimant before them. Some Claimants will lie or exaggerate to increase the value of their claim. The first step for a Court is to decide what weight they can give the Claimant's complaints and that will depend in substantial part on how truthful and how accurate they assess the complaint to be. When I come, later in this judgment, to assess a claim in respect of tinnitus I will conduct that exercise.

649. The second category is evidence as to possible causes of tinnitus and in particular evidence as to the possible causative significance of exposure to noise. The parties agree that tinnitus arising during exposure to hazardous noise will normally be attributed to such exposure. The distinct characteristics of military impulsive noise (weapons fire, explosions etc) are known to produce somewhat higher tinnitus rates than continuous industrial noise; Axelsson et al (1992) observed tinnitus in 63–70% of impulsive-noise-exposed populations, as against 47–57% in continuous-noise groups.

650. Third is evidence as to prevalence of tinnitus considered by age of the individual concerned. Mr Steinberg accepts that tinnitus occurs in the general population, but submits that it is relatively uncommon, particularly in younger adults. Mr Cox and Mr Green agree that prevalence varies with age: around 5% among ages 20–30 but rising to roughly 12% in those over 60, with an upper estimate around 15% in adults. I accept that evidence.

651. Fourth, and potentially of particular weight, would be the evidence as to late onset tinnitus in former members of the military or others exposed to impulsive noise. Studies of spontaneous, or unexplained, tinnitus in adults who were not exposed

to noise (Axelsson & Ringdahl; Coles; Quaranta; Walsh & Clark) consistently show rates between 10% and 14.5%. It would be helpful if that could be compared with evidence as to spontaneous onset of tinnitus amongst former members of the military or others exposed to impulsive noise. In the forest of academic literature with which I was supplied, little goes to this issue.

652. Delayed onset tinnitus is described by Henry et al in *Progressive Tinnitus Management* published in 2010 in the following terms:

> Delayed onset tinnitus is thought to occur weeks, months, or even years following some precipitating event (eg exposure to loud noise…). It is not uncommon for patients to make a claim of delayed onset tinnitus for litigation purposes. The possibility of such a claim being valid relates to the complex interaction among the presumed precursor event and more recent events that might have triggered the tinnitus onset. Evaluating a claim of delayed onset tinnitus requires taking a detailed history that covers all possible circumstances that might have caused damage to the auditory system. <u>A better understanding of the mechanism of tinnitus generation is needed before the existence of delayed onset of tinnitus can be positively confirmed or rejected</u>...It does seem likely that noise exposure... that could have caused auditory damage can result in delayed onset tinnitus, even when that illness onset occurs years after the event. (emphasis added)

653. The best of the other material to which I was referred, is probably chapter 17 of the rather dated Tinnitus Handbook published in 2000. That chapter was written by Prof. Ross Coles, a renowned expert in tinnitus.

> Noise-induced tinnitus can probably arise years after the period of unprotected noise exposure has ceased. The argument is as follows. Epidemiological evidence (Coles et al., 1990; Davis et al., 992; Chapter 1) indicates that what matters most in the prevalence of troublesome or persistent tinnitus is the amount of hearing disorder, as measured by the hearing threshold levels at the higher frequencies, rather than the actual cause of the disorder such as aging or noise exposure. Causes lose their significance as determinants of tinnitus prevalence, once account is taken of the high tone hearing loss.... Thus if the cause of the hearing loss is a cumulation of noise-induced and age-related disorders then it is probable the tinnitus coming on years after a period of noise exposure has ceased is due to that cumulated disorder, that is, noise damage as well as the age-related degeneration…
>
> Take as an example a man aged 25 years with a considerable degree of NIHL whose hearing thresholds at 4 kHz are 45 dB HL. He then moves to quiet work. At age 40 years, he gradually develops a troublesome high pitch ringing tinnitus. Investigation reveals that his hearing losses increased by 5 dB to 50 dB, what might be expected from ageing increments. It seems wholly unreasonable and biologically unlikely to postulate that the cause of tinnitus is associated solely with just the 5 dB of age-related hearing loss and has nothing to do with the underlying noise damage sufficient to cause 45 dB of the 50 dB hearing loss.

654. It is of note that Henry et al, the authors of the handbook, do not cite any authority or previous study in support of the suggestion that delayed onset tinnitus occurs. And Prof. Coles relies, not on scientific studies, but analysis of a hypothetical example. I was not taken by Mr Steinberg to any study that describes a cohort of former members of the military who suffered late onset tinnitus.

655. On the other hand, none of the public authorities that suggest there should be a cut-off point of one year after the cessation of noise provide any authority or scientific studies in support of that contention. That is true in respect of the Irish, American and UK organisations on which Mr Platt relied. Mr Green the Defendant's ENT expert was willing to contemplate that a gap of 18 months, or even four years, would not necessarily justify rejecting a claim; whereas Mr Cox would impose no time limit at all on such a claim.

656. Nonetheless, in my judgment it is impossible to conclude, and no one now suggests, that tinnitus might not begin shortly after the cessation of noise. The expert evidence I heard would not support the imposition of a cut-off point of less than a year. In fact, I see no logical basis on which any arbitrary stop line could properly be imposed, beyond which a claim could not even be considered.

657. In my judgment, the most that can be said is that the closer the onset of tinnitus is in time to the exposure to dangerous noise, the more likely it is to be caused by it. The longer the period between the end of exposure and the onset of tinnitus the greater should be the intensity of the examiner's scrutiny of the circumstances of the case and the veracity of the informant. And the Court, faced with a disputed claim, will have to be equally circumspect.

Chapter 13 – De Minimis Hearing Loss

658. In this chapter I consider whether there is a measurement of hearing threshold change, or other measure, that delineates the borderline between material and *de minimis* damage.

659. The Claimants invite the Court to conclude:

- There is no specific measurement of hearing threshold change in dB that delineates the borderline between material and *de minimis*.
- In difficult or borderline cases, what amounts to *de minimis* is necessarily a question of fact, which will need to be resolved on a case-by-case basis.

660. The Defendant invites the Court to conclude that:

- The issue of *de minimis* was not canvassed in evidence and was not argued in any of these surviving lead cases.

661. I have already ruled, early on in the hearing, that I should address this issue because it arises, at least arguably, in the case of Craggs. That decision has not been challenged. I note that the Defendant has made detailed, and helpful, submissions on the issue which I address below. The matter can, however, be dealt with fairly briefly because it turns on submissions alone.

The Evidence

662. The ENT experts' agreed view in their joint report was that an excess loss between 4 and 5 dB is likely to be noticeable by some individuals and should be regarded as significant in a medicolegal context.

663. However, this view was subject to three caveats. Firstly, it was agreed that there is a lack of scientific studies that address this issue directly. As such, there is a range of opinion on this issue among medical experts.

664. Secondly, Mr Green, in his individual report, highlighted that, for individuals who do not notice hearing loss for ten years or more after the cessation of noise exposure, excess hearing loss attributable to noise by definition is not noticeable. Rather, it is the addition of hearing loss from other causes, most commonly age-associated hearing loss, that causes hearing loss to become noticeable at an earlier stage than it would be otherwise.

665. Thirdly, it was agreed that some individuals experience symptoms of hearing impairment when the hearing levels would be considered to be within the normal audiometric range. Indeed, in Mr Green's oral evidence during the Primer session, he emphasised that audiograms only test an individual's ability to detect tones rather than speech.

The Competing Submissions

666. Mr Steinberg contends that materiality turns on whether the Claimant is 'appreciably worse off' as a matter of objective fact, rather than subjective perception. He relies on Cartledge v E Jopling & Sons Ltd [1963] AC 758 (*"*Cartledge*"*) and Dryden v Johnson Matthey PLC [2018] UKSC 18 (*"*Dryden*"*) to show that harm may be hidden yet still actionable.

667. He notes that Mr Cox and Mr Green agree that 4–5 dB of excess loss may be noticeable by some individuals, but argues that noticeability is not determinative of materiality. He highlights Mr Green's oral evidence that anything above ~4.5 dB is material, with 10 dB being significant.

668. Mr Steinberg stresses that pure-tone audiometry only measures tone detection and does not assess speech recognition. He notes Mr Green's evidence in the primer session that audiometry is a subjective test and correlates imperfectly with functional hearing ability. He refers to the Defendant's policy JSP 346/950 which acknowledges that hearing acuity does not equate reliably with hearing function. He says that there is no good science that assigns a particular dB change in threshold to what he refers the "low fence" between material and *de minimis*.

669. Material harm may arise even without present threshold shift because noise exposure drains the cochlear reserve ('years to the ears'). A threshold-only analysis ignores this mechanism of injury.

670. Mr Steinberg argues that applying a 4:1 binaural ratio can understate disability in asymmetrical cases. He cites Mr Hambridge, where the experts agreed the loss was significant despite the Defendant's binaural calculation producing a *de minimis* figure.

671. The hearing-aid experts confirm variability in speech-in-noise difficulty even among those with normal thresholds. Accordingly, materiality, he argues, is a case-by-case factual question, and no universal dB threshold marks the line between material and *de minimis*.

672. Mr Platt relies primarily on the House of Lords decision in <u>Rothwell v Chemical and Insulating Co. Ltd</u> [2007] UKHL 39 ("<u>Rothwell</u>"), which establishes that actionable damage must make a Claimant "appreciably worse off". Merely minimal or negligible injury does not suffice. The law thus requires 'real' damage, not trivial or imperceptible physical effects.

673. He says that there is broad consensus among experts (Green, Cox, Lutman, Moore) that individuals generally cannot notice incremental changes in hearing of less than roughly 4–5 dB over key frequencies. These thresholds are based on pure-tone audiometry and supported by scientific literature, including McShefferty's studies.

674. Mr Platt argues that although some studies (e.g., Brungart 2025) suggest subclinical noise damage may cause symptoms despite normal audiograms, experts in neurophysiology (Plack and King) caution that such studies lack objective measures and histological confirmation. They conclude that current science cannot reliably attribute subclinical symptoms such as tinnitus or speech-in-noise difficulty to synaptopathy. Accordingly, synaptopathy cannot be used to bypass the *de minimis* principle.

675. Mr Green observes that NIHL often becomes noticeable only when combined with age-related loss years later. Mr Platt argues that even if the total hearing loss is perceptible, it does not follow that a small NIHL component (1–2 dB) accelerated that perception measurably. Experts agree that losses below approximately 4 dB would not be noticed and therefore would not make an individual appreciably worse off.

676. Based on expert evidence, the Defendant concludes that binaural NIHL below 4 dB at 1/2/3 kHz should be regarded as *de minimis*. For example, Mr Craggs' alleged NIHL of 1–1.5 dB would not be material and would not justify compensation.

Discussion

677. There is no real dispute on the law on this issue which was settled by the decision of the Supreme Court in Dryden. Lady Black, in a judgment with which the other members of the Court agreed, explained the distinction between the two leading House of Lords decisions, Cartledge and Rothwell upon which Mr Steinberg and Mr Platt rely. In Cartledge, the inhalation of silica particles had damaged the lung tissue of the Claimants causing minute scars and reducing the efficiency of the lung tissue. That was sufficient to found a claim. In Rothwell, the pleural plaques were not in any way harmful to a sufferer's health or physical condition. They were evidence that the lungs had been penetrated by asbestos fibres, but they did not, themselves, give rise to actual or prospective disability. Accordingly, they did not found a claim.

678. Lady Black noted that in Rothwell it was held that to be actionable, the damage had to be more than negligible. "*This is expressed in various ways, including that it must be more than trivial (Lord Hoffmann, at para 8), that it must be "real damage" (Lord Hope of Craighead, at para 39), and that it must be material (Lord Rodger of Earlsferry, at para 87).*" Lord Hoffman said (at para 7) that the relevant question was whether the Claimant is "*appreciably worse off in respect of his "health or capability".* In Dryden, Lady Black adopted a conclusion in Cartledge that the damage "*can be hidden and symptomless*" but still be actionable.

679. Here, in my judgment, the expert evidence establishes that 4–5 dB of excess loss may be noticeable by some individuals. A hearing loss of less than 4dB would not be noticeable and, if that measure is taken alone, would be *de minimis* because the Claimant experiencing such a loss would not be appreciably worse off.

680. However, as Mr Steinberg correctly submits, hearing acuity does not equate necessarily or completely with hearing function. There may be other consequences of exposure to noise which do leave a Claimant appreciably worse off. I have rejected the possibility of founding a claim on latency in chapter 10 or on synaptopathy in chapter 11. But I do not exclude, for example, the possibility that a Claimant with a hearing loss measured at less than 4 dB might nonetheless be able to establish that the deterioration of his ability to detect speech amounts to an appreciable loss.

681. In conclusion, a hearing loss of less than 4 dB on a binaural calculation for either 1, 2 and 3 kHz or 1, 2 and 4 kHz without other consequences should be regarded as *de minimis*. It will be a matter to be determined on a case-by-case basis whether exposure to noise which causes loss below that cut off nonetheless causes appreciable damage.

Chapter 14 – General Damages

682. In this chapter, I make some general observations on the proper approach to the assessment of general damages for pain, suffering and loss of amenity (PSLA) in NIHL cases. I share the view of both counsel that the exercise of assessing general damages is intensely case specific and I will leave to subsequent chapters my assessments in respect of the remaining two lead claims.

683. The Claimants invite the Court to conclude that:

- NIHL in excess of 10 dB (binaural average over 1,2,4 kHz or 1,2,3 kHz) justifies an award of general damages for PSLA in the range of £19,667 to £39,226 depending on the individual circumstances.
- NIHL in excess of 20 dB (binaural average over 1,2,4 kHz or 1,2,3 kHz) justifies an award of general damages for PSLA in the range of £39,226 to £60,115 depending on the individual circumstances.

684. The Defendant articulates no proposed finding on this issue but makes some general observations including that:

- As a matter of principle, no awards should be made for theoretical injury such as synaptopathy or future acceleration of hearing loss even if proven in principle. Only damage that is quantifiable is susceptible to monetary compensation.

The Competing Submissions and the Evidence Relied On

685. Mr Steinberg argues that the Judicial College Guidelines (17th ed.) ("the JC Guidelines" or "the Guidelines") provide the framework for any assessment of general damages, but stresses that they require consideration of factors including age at onset, duration of exposure, speech effects, balance impairment, occupational impact, and whether tinnitus is suffered alone or with NIHL.

686. Both he and Mr Platt adopt updated figures to reflect the effect of inflation. Mr Steinberg argues that proper application of the Guidelines should result in higher-end placement when functional impact is significant.

687. He relies on Barry v MoD [2023] EWHC 459 (KB), where the updated award was £30,511 for NIHL of 20.3 dB with tinnitus; Inglis v MoD [2019] EWHC 1153 (QB), with an updated award of £35,218 for NIHL of 16–17.7 dB with intrusive tinnitus; and C v Pegasus Heating (2023), with an updated award of £24,297 for 9 dB NIHL with severe tinnitus. He argues these cases show the appropriate awards in cases with modest audiometric losses but major functional effects.

688. He contends that listening effort, cognitive fatigue, social withdrawal, occupational difficulty, early need for hearing aids, and loss of confidence may all be relevant and justify higher placement in the relevant brackets.

689. He submits that NIHL exceeding 10 dB should fall within the Moderate tinnitus/NIHL bracket (£19,667–£39,226). In severe cases such as Lambie, with NIHL values of 26–43 dB and moderate/severe tinnitus, the suitable bracket is Severe tinnitus and NIHL (£39,226–£60,115).

690. Mr Platt agrees that the JC Guidelines govern assessment of general damages. He notes that Chapter 5(B)(d) provides the relevant brackets for partial hearing loss and/or tinnitus. He emphasises the need to apply RPI uplift of 8.26% to bring nominal bracket values to current levels. He highlights the fact that the Guidelines closely mirror the US ASHA's threshold definitions (none, slight, mild, moderate, moderately severe, severe, profound) and that tinnitus descriptors are consistent with the commonly deployed McCombe Scale. He argues this objective structure assists in determining the place of an individual case in the relevant range.

691. He sets out the six relevant sub-brackets, ranging (after uplift) from 'up to £9,267' for slight NIHL/tinnitus to £39,255–£60,160 for severe tinnitus with NIHL. He submits that although PSLA is subjective, these brackets remain the principal guide.

692. In Mr Lambie's case, NIHL is accepted and the parties' figures are £45,000 (Claimant) vs £30,000 (Defendant). For Mr Craggs, causation is disputed; the Claimant proposes £30,000. This, Mr Platt says, illustrates the Guidelines' role in promoting consistency.

693. Mr Platt argues that no award should be made for theoretical or unquantified injuries such as synaptopathy or theoretical acceleration of presbycusis. Only quantifiable, proven injury should attract compensation.

The Guidelines

694. The relevant part of the JC Guidelines for Partial Hearing Loss and/or Tinnitus provide as follows. The underlined figures in the table below have been updated to account for inflation

> This category covers the bulk of deafness cases which usually result from exposure to noise at work over a prolonged period. The disability is not to be judged simply by the total measurement of hearing loss; there is often a degree of tinnitus present and age is particularly relevant because impairment of hearing affects most people in the fullness of time and impacts both upon causation and upon valuation, such that the amount of noise-induced hearing loss ('NIHL') is likely to be less than an individual's total hearing loss.
>
> (i) Severe tinnitus and NIHL.
>
> <u>£39,226 to £60,115</u> (£36,260 to £55,570)
>
> (ii) Moderate tinnitus and NIHL or moderate to severe tinnitus or NIHL alone.
>
> <u>£19,667 to £39,226</u> (£18,180 to £36,260)
>
> (iii) Mild tinnitus with some NIHL.
>
> <u>£16,627 to £19,667</u> (£15,370 to £18,180)

(iv) Mild tinnitus alone or mild NIHL alone.

Around £15,470 (£14,300)

(v) Slight or occasional tinnitus with slight NIHL.

£9,617 to £16,519 (£8,890 to £15,370)

(vi) Slight NIHL without tinnitus or slight tinnitus without NIHL.

Up to £9,260 (£8,560)

Discussion

695. Both parties rely on the Guidelines, accept RPI uplift, and recognise the subjective nature of the exercise. Mr Platt favours discipline, objective thresholds, and avoidance of speculation. Mr Steinberg emphasises functional reality, psychological impact, and the exacerbating effect of NIHL occurring at a young age. There is force in all those submissions.

696. However, the Guidelines are the starting point for the assessment in any individual case. In deciding where the case falls within those Guidelines the Court will have regard to all the circumstances of the case. That is likely to include recognition of the fact that real-world impairment may often exceed what pure audiometry suggests. Mr Platt's caution against compensating theoretical injuries is appropriate, but Mr Steinberg's emphasis on functional evidence is equally consistent with the Guidelines.

697. In any event, I see no justification for replacing or amending the Guidelines so as to ascribe damages brackets to particular levels of hearing loss as Mr Steinberg proposes. The Guidelines provide the appropriate guidance. The judge's task is to consider all the facts of the case in question against those guidelines. The dB measure of NIHL is a highly relevant factor but is not necessarily determinative of the appropriate damages bracket.

698. It is to be noted that, on their face, the Guidelines address the effect of age in one respect; "*age is particularly relevant because impairment of hearing affects most people in the fullness of time and impacts both upon causation and upon valuation, such that the amount of noise-induced hearing loss ('NIHL') is likely to be less than an individual's total hearing loss*". On the other hand, the Court has to bear in mind that age related deterioration adds to the hearing loss suffered as a result of noise exposure. As Mr Steniberg puts it "*the effect of aging will have a greater effect on the ears*" of a Claimant already damaged by noise. Furthermore, the younger a Claimant is when the NIHL occurs, the longer he may have to live with hearing aids and the longer he is likely to have to live with the disability.

699. A Claimant who suffers both NIHL and tinnitus is affected more severely than one who has the one without the other. As is clear on its face, the highest category

of award under the Guidelines is appropriate for someone who has suffered from both conditions to a severe degree. Category (ii) is appropriate for a Claimant who has suffered moderate to severe NIHL but no tinnitus, the top of that bracket being appropriate if the NIHL is severe, the bottom if it is moderate. All such assessments, however, are not the product simply of the mechanical application of the JC Guidelines; all involve a judgment on the specific facts of the case.

700. In those circumstances, I conclude that the JC Guidelines are the appropriate starting point for assessing general damages for PSLA. The judge's task is to consider the facts of the case against those guidelines. The dB measure of NIHL is a highly relevant factor but is not necessarily determinative of the appropriate damages bracket.

Chapter 15 – Hearing Aids

701. In this chapter, I address some questions common to Claimants who seek to recover the costs of hearing aids.

702. The Claimants invite the Court to conclude that:

- A Claimant shall be awarded the cost of private, high-performance, rechargeable hearing aids with advanced features when such aids are recommended by a reputable Hearing Aid Expert.
- The current cost of private, high-performance, rechargeable hearing aids with advanced features is about £5,000, including consultation and extras such as domes or wax guards.

703. The Defendant admits that in principle the cost of obtaining hearing aids privately may be recoverable but says it will be a decision for individual cases whether awards should be made.

The Evidence

704. The expert evidence on this topic was provided by the ENT experts and by registered hearing-aid dispensers.

705. In their joint report, the ENT experts, Mr Cox and Mr Green, recognised that hearing aid fitting strategies and outcomes are outside their area of expertise. The role of an ENT surgeon instead is usually confined to an initial assessment (in cases where the patient is not directly referred to audiology) and referral for assessment of hearing aid candidacy. They agreed that hearing aids do not restore hearing to normal levels, and difficulties with speech perception, particularly in background noise, contribute to relatively low usage of hearing aids. Nevertheless, hearing aids can be effective in improving communication and listening abilities as well as overall quality of life. Mr Green, in his individual report, pointed out that hearing aid users of working age may be more committed to using hearing aids regularly, and therefore were associated with better outcomes.

706. For the Claimants, evidence on hearing aid dispensing was given by Mr Hussnain, Mr Robertshaw and Dr Mahmood, while the Defendant relied on the evidence of Dr Nassar. Their evidence addressed the clinical indications for hearing aids; the appropriate criteria for offering such devices; the comparative value of subjective and objective measures of hearing difficulty; the nature of the benefit that modern hearing aids can provide; the continuing limitations even with optimal amplification; the practicalities of hearing-aid fitting and follow-up; the technology available in high-performance private devices; the costs and likely replacement cycle of such devices; and the typical age at which men not subject to noise exposure would require hearing aids due to age-related decline.

707. It was common ground that the NICE guidelines form the appropriate clinical framework for determining when hearing aids should be considered. These guidelines emphasise that hearing aids should be offered to adults whose hearing loss affects their ability to communicate and hear in daily life, and expressly recognise that an individual's self-reported hearing difficulties carry as much weight as measured audiometric thresholds. The experts also agreed that there is no fixed level of hearing loss, expressed in decibels, which must be met before

hearing aids can be justified. They accepted that two individuals with identical audiograms may differ substantially in the degree of functional difficulty they experience, and that clinical judgment must therefore rely significantly on the Claimant's own description of their symptoms.

708. The experts also agreed that hearing-aid benefit cannot be predicted reliably from an audiogram. Pure-tone thresholds measure the softest level at which tones of particular frequencies can be detected in a quiet environment, but these thresholds do not reflect an individual's ability to hear speech in complex acoustic settings, particularly in the presence of background noise. The British Society of Audiology's recommended procedure makes clear that pure-tone thresholds cannot be used as the sole determinant of whether hearing support is required. All experts therefore accepted that the only reliable method to determine whether an individual will benefit from hearing aids is to conduct a formal hearing-aid trial using modern devices programmed to the individual's needs.

709. The experts agreed that modern, privately-supplied digital hearing aids—particularly when worn bilaterally—can provide significant benefits. These include: improved audibility of speech, especially in background noise; improved localisation of sound sources; enhanced clarity and sound quality; and, in some cases, reduced tinnitus awareness. Modern devices incorporate sophisticated technology such as noise-cancellation algorithms, directional multi-microphone arrays, advanced speech-processing software, frequency-lowering systems and self-learning adaptation features. These features are designed to optimise performance in real-world listening environments rather than merely amplifying sound.

710. Notwithstanding these benefits, the evidence also reflected a shared understanding of the limitations of hearing aids. No expert suggested that hearing aids can restore hearing to normal. Even with advanced features and optimal fitting, individuals may continue to experience difficulties hearing speech in noisy environments. The experts emphasised that hearing aids aim to improve functional hearing, not to cure or reverse sensorineural loss.

711. The experts provided detailed evidence on the importance of appropriate fitting, verification and follow-up for ensuring optimal outcomes. This includes real-ear measurements, iterative tuning based on the patient's subjective feedback, and ongoing support during the adjustment period. They indicated that independent private dispensers are often able to provide the time-intensive, individualised care required to achieve these outcomes, including extended follow-up across the lifespan of the devices.

712. Evidence regarding costs demonstrated that high-performance digital hearing aids typically cost between £4,660 and £5,000, inclusive of consultation fees, consumables such as guards and domes, and long-term warranties. Oral evidence from Dr Nassar indicated that the cost of such devices has increased recently, and that a typical overall cost is now approximately £4,660 – £5000 per five-year replacement cycle. The experts agreed that hearing aids generally require replacement every five years due to technological obsolescence, wear and tear, and battery degradation in rechargeable models.

713. The evidence further established that the typical age at which men would require hearing aids due solely to age-related decline is around 75 years. The claims in

this litigation concern individuals who have suffered noise-induced hearing loss, necessitating the use of hearing aids substantially earlier than would have been required in the absence of injury.

Submissions

714. Mr Steinberg submitted that the evidence establishes a compelling clinical case for the provision of private, high-performance bilateral hearing aids to the Claimants. He emphasised that the NICE guidelines and the expert evidence show that the prescription of hearing aids cannot be confined to a mechanical threshold of decibels. Instead, consistent with the experts' concessions, he argued that self-reported functional difficulty is a central consideration, and that reliance solely on audiometric thresholds is inappropriate. He submitted that because benefit cannot be predicted from an audiogram, the requirement for a hearing-aid trial—accepted by all experts—confirms the need for aids where Claimants report functional difficulties consistent with their clinical presentations.

715. He placed particular reliance on the evidence demonstrating that modern high-performance devices offer meaningful benefits in the areas most commonly affected by noise-induced hearing loss: speech-in-noise discrimination, sound localisation and reduction of listening effort. He submitted that the advanced technological features available in the recommended devices justify their cost, and that private provision is reasonable because optimal outcomes depend heavily on extended, individualised fitting and follow-up, which private dispensers are best placed to provide.

716. As to cost, he argued that the range identified in the evidence—between approximately £4,660 and £5,000—constitutes a reasonable estimate of the Claimants' likely expenditure, especially in light of the recent increases described by Dr Nassar. He submitted that the claims represent accelerated need, since the Claimants would otherwise not have required hearing aids until around age 75. He invited the Court to accept the Claimants' schedule of loss reflecting these costs and replacement cycles.

717. Mr Platt accepted that the cost of private hearing aids may, in principle, be recoverable but submitted that the issue must be determined on a case-by-case basis. He relied on the principle in Woodrup v Nicol [1993] PIQR Q104 (CA) and submitted that even where hearing-aid provision may be clinically reasonable, the Court must consider whether the individual Claimant would in fact purchase private aids.

718. He emphasised the limitations acknowledged in the evidence: hearing aids do not restore normal hearing, and significant difficulties may persist, particularly in noisy environments. He argued that these limitations mean that the Court should be cautious before awarding substantial sums for high-performance devices, especially where the evidence does not demonstrate clearly that such devices offer significant advantages over NHS-provided aids for the individual in question.

719. Mr Platt further submitted that the evidence does not support any universal threshold—whether audiometric or age-based—for determining when hearing aids should be prescribed or when accelerated need begins. He argued that benefit, need and intention must all be assessed individually, and that the Court should not adopt generic guidance. As to cost, he noted the evidence that typical

replacement-cycle costs have risen to approximately £4,200 every five years, and indicated that the Defendant does not resist an award based on that figure where properly established. He also submitted that additional equipment, such as assistive listening devices, should only be awarded where there is clear and specific justification.

Discussion

720. The submissions of counsel present contrasting approaches to the application of the expert evidence: Mr Steinberg relies on the general consensus of the experts to support an overarching conclusion that private, advanced hearing aids are justified across the Claimants' cohort, whereas Mr Platt urges a more cautious and individualised approach grounded in the requirement for proof of actual intention to make the purchase, demonstrable benefit and proportionality in cost.

721. In my view, there is force in both approaches.

722. The starting point is, as Mr Platt submits, s2(4) of the Law Reform (Personal Injuries) Act 1948:

> In an action for damages for personal injuries… there should be disregarded, in determining the reasonableness of any expense of the possibility of avoiding those expenses or part of them by taking advantage of facilities available under the National Health Service.

723. Where a Claimant requires medical treatment arising out of a compensable injury, they are entitled to obtain that treatment privately irrespective of the availability of state funded care. However, a Claimant must prove their intention to utilise private medical services rather than the NHS (see the judgment of Russell LJ in Woodrup v. Nicol [1993] PIQR Q104 (CA)).

724. As to the cost of hearing aids, the hearing aid dispenser experts proceed on the basis of a 5 year replacement cycle and that seems to me reasonable. The experts differed as to the precise cost 5 yearly cost but that appears to be in the region £4,200- £5,000 including fitting and adjustment. The precise cost in an individual case will depend on the evidence in that case.

725. I agree with Mr Platt that the evidence does not support any universal threshold for prescription by reference to numbers of decibels. Whether or not an individual will benefit from the use of hearing aids will be a matter of fact to be determined in each individual case and there is no helpful generic guidance which the Court can give in this regard. Similarly, the age threshold at which an individual would have required hearing aids on the "but for" scenario cannot be determined generically. I also agree with Mr Platt that the necessity for ancillary equipment (e.g. the Roger microphone) will be a case specific issue. The Court will require specific justification for the expenditure on the facts of the particular case.

726. In my judgment, depending on the evidence in a particular case, a Claimant may be able to justify the cost of private, high-performance, rechargeable hearing aids with such advanced features as are recommended by a reputable Hearing Aid Expert. The current cost of such hearing aids with advanced features is in the region £4,200 – £5,000, including consultation, and consumables such as domes or wax guards. The precise costing will have to be determined on a case-by-case basis.

Chapter 16 – Loss of Future Earnings

727. The issues arising from a claim for loss of future earnings in a NIHL case are best considered against the facts of a particular case. Accordingly, I address the topic on the facts of the one case in which it arose before me, namely that of Mr Lambie.

Chapter 17 – Conclusions on Generic Issues

728. For the reasons discussed in the proceeding chapters, I have reached the following conclusions on the generic issues:

729. **Specificity and Sensitivity.** In my judgment, little weight should be attached to either specificity or sensitivity figures. They should be considered as no more than 'ballpark' estimates.

730. PPV figures are more helpful than either the sensitivity or specificity figures alone. But that does not mean that decisive weight should be attached to the PPV figures either. That that approach is the right one is underlined by the fact that all these statistics depend on audiograms and all the suggested diagnostic methods are expressly intended as guidelines only. All require consideration of the whole clinical picture.

731. **Military Audiograms.** Pure Tone Audiometry (PTA) conducted in compliance with the protocol and standards set by the British Society of Audiology (BSA) is the gold standard of audiometric testing and should be used in medico-legal cases as the best evidence whenever it is available. However, screening audiograms, including military screening audiograms, are ordinarily suitable for screening and triage. Furthermore, when they are part of a consistent pattern they may also be used, as part of the exercise of clinical judgment by clinicians advising in medico-legal cases, for diagnostic and quantification purposes. Audiometry evidence (including BSA compliant PTA) should, wherever possible, be considered in context and as a whole, rather than in isolation.

732. The arrangements operated by the MoD were and are designed to give a good degree of oversight over the hearing capacity of members of the armed forces. The majority of such audiograms are conducted properly and in good faith. This is particularly so once a referral for medical assessment is made. However, there may, on occasions be systemic or operational inadequacies and the Court should be alive to that possibility.

733. **The Foundational Concepts**. (i) For the purposes of both the diagnosis and quantification of NIHL, ISO 7029:2017/2024 should be preferred over ISO7029:1984/2000. (ii) A baseline correction is required in principle. In the generality, a cohort-wide allowance of 2.4 dB across 1–8 kHz should be adopted. (iii) TDH39P earphones are liable to produce variable results at the 6 kHz frequency. However, there should be no automatic deduction of 6 dB when an HTL at 6 kHz is measured using TDH39P earphones. Whenever the precise 6 kHz measurement could make a difference to the diagnosis or quantification of NIHL, the ENT expert should approach the measurement with caution and assess it in the context of the audiometric series of which it forms part.

734. **The Diagnostic Method** to be preferred is the rM-NIHL method. CLB is not generally suitable for military cases.

735. **Quantification.** The Moore, Cox and Lowe method of quantification is to be preferred. In using that method (i) the choice of the **percentile** in the relevant dataset should be dictated by the clinical judgement of the medicolegal ENT surgeon based on the hearing of the individual ascertained from all the available

audiometry; (ii) the conventional **1, 2, 3 kHz average** should continue to serve as a baseline descriptor. However, it is entirely legitimate to consider supplementary metrics that incorporate 4 kHz, particularly where speech-in-noise difficulty is a prominent feature. (iii) NIHL should generally be quantified **using the 4:1 binaural calculation**. But where the excess loss calculation does not fully reflect the totality of the problems experienced by the Claimant, the clinician, and ultimately the Court, needs to identify and reflect the additional disability.

736. **Latency and Acceleration.** The theory that hearing loss may continue to develop after exposure is plausible, intellectually coherent but a very long way from being proven in human beings. The orthodox view that hearing loss does not progress after exposure ceases has not, at least at yet, been displaced. Further, and more fundamentally, there is at present no conceivable mechanism by which the effect of this alleged phenomenon could be identified or quantified in any individual Claimant.

737. **Cochlear Synaptopathy** cannot definitively be demonstrated, let alone quantified, in humans before death. 'Proxy measures' of cochlear synaptopathy are less than certain and there is no gold standard test for the condition.

738. **Tinnitus.** Tinnitus normally begins during exposure to noise or shortly after the cessation of noise. It is not possible to identify an arbitrary time after exposure to noise beyond which a claim should not be considered. The most that can be said is that the closer the onset of tinnitus is in time to the exposure to dangerous noise, the more likely it is to be caused by it. The longer the period between the end of exposure and the onset of tinnitus the greater should be the intensity of the examiner's scrutiny of the circumstances of the case and the veracity of the informant. And the Court, faced with a disputed claim will have to be equally circumspect.

739. **De Minimis**. A hearing loss of less than 4 dB without other consequences should be regarded as *de minimis*. It will be a matter to be determined on a case-by-case basis whether exposure to noise which causes loss below that cut off nonetheless causes appreciable damage.

740. **General Damages.** The JC Guidelines are the appropriate starting point for assessing general damages for PSLA. The judge's task is to consider all the facts of the case in question against those guidelines. The dB measure of NIHL is a highly relevant factor but is not necessarily determinative of the appropriate damages bracket.

741. **Hearing Aids.** Depending on the evidence in a particular case, a Claimant may be able to justify the cost of private, high-performance, rechargeable hearing aids with such advanced features as are recommended by a reputable Hearing Aid Expert. The precise costing will have to be determined on a case-by-case basis.

742. **Loss of Future Earnings.** Such claims are highly fact sensitive, and the relevant principles are best considered in the context of a particular case. I do so in the case of Mr Lambie in the next chapter.

PART 3

Chapter 18 – Mr Christopher Lambie

Introduction

743. Mr Lambie's was the first of the two lead cases which remained for decision out of the original cohort of test cases. In his case, liability was admitted subject to a 10% discount on application of the Matrix agreement, which, as it will be recalled, reflected the compromise between the parties on crown immunity, combat immunity, breach of duty, contributory negligence, apportionment, Noise Imission Level and limitation.

744. Until shortly before the hearing quantification of NIHL was also disputed in Mr Lambie's case. However, in a Note to the Court dated 8 October 2025, Mr Platt, on behalf of the Defendant, made a formal admission to the effect that the Defendant would not contest the quantification of NIHL in this case. Accordingly, the quantification is agreed at the figure set out by Mr Silva in the joint statement of the ENT experts, namely:

For the January 2022 audiogram:

- Over 1, 2 & 3 kHz; the right and left ear thresholds are 38.8 dB and 42.1 dB respectively.
- Over 1, 2 & 4 kHz, the right and left ear thresholds are 38.4 dB and 43.4 dB.

For the August 2024 audiogram;

- Over 1, 2 & 3 kHz; the right and left ear thresholds are 34.4 dB and 37.8 dB respectively.
- Over 1, 2 & 4 kHz, the right and left ear thresholds are 34 dB and 42.4 dB respectively.

745. It follows that the issues in dispute were general damages for pain, suffering and loss of amenity (PSLA), hearing aid costs, and future loss of earning capacity.

746. In summary, the Claimants invited the Court to conclude that:

- The appropriate award for PSLA was £45,000
- The award for hearing aids should be £27,350; and
- The award for loss of future earnings should be £370,003.

747. The Defendant says that the appropriate awards are:

- £30,000 for PSLA
- £26,905.26 for hearing aids; and
- Zero for loss of future earnings or future earning capacity.

The Evidence

748. Mr Lambie provided three witness statements, the accuracy of which he confirmed in his oral evidence.

Service in the Cadets

749. Christopher Lambie was born on 2 April 1980. He is now 46 years old.

750. In his first witness statement, Mr Lambie said that he joined the Lincolnshire Army Cadets at around the age of sixteen, and it was there that he first encountered prolonged noise from weapons. He recalls attending firing ranges approximately twenty times, each time firing between thirty and sixty rounds from the L98 Cadet rifle, a weapon with similar acoustic properties to the SA80. During these range days, he was often positioned in troop shelters close to other cadets who were firing rifles. He says that hearing protection was provided inconsistently and often not at all. On some occasions he received yellow foam earplugs, but on many he did not. He had no training in how to use hearing protection or why it mattered. He also took part in exercises involving blank rounds, which added to his cumulative exposure.

751. In his oral evidence he described live-firing and weapon-handling practices during his time as a cadet where ear defenders were not always worn, or one ear plug had to be removed to communicate over radio headsets. He said he later 'scraped through' at the Royal Marines entry hearing test in 1998.

Service in the Marines

752. He enlisted in the Royal Marines in September 1999. Basic training was physically demanding and exposed him to extremely loud noise. Although hearing protection was nominally available, he said the quality varied significantly, supplies were inadequate, and the defenders issued were often worn out. During training, Marines queued at stores and were handed whatever equipment happened to be in the bin, unable to assess its condition before use. Much of the firing training, including SA80 rifle practice and heavy machine-gun exposure, took place under conditions where hearing protection was either optional, impractical, or incompatible with the need for situational awareness.

753. Mr Lambie served as a General Duties Marine, and later in various Intelligence Cell roles. His career included deployments to Northern Ireland, Iraq (Op Telic), and Afghanistan (Op Herrick), as well as major training exercises in Egypt, Cyprus, Norway, the United States, and Gibraltar. Each of these postings involved further noise exposure, live firing, blank firing, vehicle and aircraft noise, heavy weapons, and sudden explosive sounds. In Egypt he was required to fire mortar illumination rounds. He had not been made aware of how loud these rounds would be and did not wear protection for the first shot. After realising the noise level, he had no chance to insert protection because his role required him to continue firing to support the rest of the group. Even after receiving a diagnosis of noise-induced hearing loss, he was routinely placed in noisy environments with no restrictions.

754. He described an episode during training on Exercise 'Hold Fast', where he and three others were required to live in a trench for a week. The weather was awful, the trench repeatedly flooded, and sleep was limited. They were attacked multiple times, day and night. He was repeatedly exposed to the general-purpose machine gun ("GPMG") firing at extremely close range. On one occasion he acted as the No. 2 gunner feeding ammunition into weapons, so close that he felt the barrel turning red hot from the volume of fire. He emphasises that no one wore ear protection in those moments because they needed to hear commands and react promptly.

755. In his oral evidence, he said that his early service in the Marines included Exercise Argonaut in 1999, a five-month deployment aboard HMS Ocean, where he served as a 51mm mortar man. He recalled firing illumination rounds without ear protection and operating heavy machine guns with minimal ear protection.

Combat Intelligence

756. Mr Lambie told me that in 2002 he opted to specialise in the combat intelligence branch which he said did not "have a hearing requirement" and he completed specialist training in January 2003. This choice both suited his interests and mitigated the risk of further noise exposure. As soon as he qualified in 2003, he was deployed with the Regiment's intelligence cell for Telic 1. He was deployed initially in Kuwait, moved to the Kuwait–Iraq border, and crossed into Iraq as hostilities commenced. He described a forward HQ, improvised from vehicles and canvas, where the intelligence cell synthesised human and signals intelligence into assessments for commanders.

757. His last operational tour as a Royal Marine was in Helmand Province, Afghanistan. By then, he had been promoted to Sergeant. Reports recommended that he be retained as fully deployable "with double hearing protection" (foam earplugs under over-ear defenders). However, he candidly admitted he had manipulated an audiogram on 7 March 2011 to enable him to achieve the hearing test results which would allow him to be deployed to Afghanistan two weeks later. He said that was the only time he failed to respond properly during audiometric testing. By 2012, Audiology records and ENT notes suggest his hearing profile was largely stable.

Promotion in the Military

758. His progression through acting roles to Sergeant and Colour Sergeant followed appraisals which praised his intellect, communication and leadership. Successive appraisals forecast his suitability for warrant rank and commissioning. He was commissioned in 2014. As an officer he transitioned to strategic intelligence roles, predominantly but not exclusively in the UK. He later commanded Y Squadron combining operational oversight with HR and leadership responsibilities. He had some 75 personnel answerable to him.

759. He made clear that promotion was not automatic: '*You have to get the appraisal reports, be recommended, and pass the requisite command courses. They don't give it away for nothing*.' His progress was faster than average, and he believed he could have reached the rank of Commander by age 55 had he remained in the

service. He acknowledged that that was the limit of advancement "for late-entry officers".

Hearing Difficulties and Hearing Aids

760. The earliest documentary evidence of hearing loss consists of pre-enlistment audiograms from 16 July 1997 and 3 April 1998. The Claimant relies on these as demonstrating that, even before joining the Royal Marines, his hearing thresholds were already abnormally elevated, a fact he attributes to unprotected exposure to weapons fire during his time in the Cadets. His first recorded complaint of hearing difficulty occurred on 14 November 2001 when, aged only 21, he reported that he was '*struggling to hear people whispering to me even when standing close to me*'.

761. On 17 July 2002, he underwent audiometric assessment. The record states: '*Noise induced hearing loss – deterioration since last test'*. That was the first confirmed diagnosis of NIHL. He told me that no protective steps were taken by the Defendant despite a recommendation that he avoid dangerous noise levels. Mr Lambie said that he first noticed difficulty hearing quiet speech around 2004. In 2005 an ENT Consultant diagnosed noise-induced hearing loss. He was medically downgraded on 9 February 2012. A Medical Board on 27 June 2012 confirmed permanent downgrading. He has relied on hearing aids since February 2012, when he was aged just 31.

762. His symptoms included missing parts of conversations, needing repetition, relying on lip cues, difficulty with background noise, and exhaustion from constant listening effort. Social situations became very difficult. He often misheard or failed to hear questions. During COVID, masks prevented him from using visual cues and left him unable to understand many people. His wife frequently had to interpret for him, both in shops and restaurants. Phone calls were nearly impossible without a loudspeaker, which caused frustration in the household. Car journeys became silent and tense because of the danger posed when he turned to face the speaker.

763. Mr Lambie began using hearing aids in 2012. The first MoD in-ear pair was discreet and immediately improved environmental awareness, though they amplified all sound and were overwhelming in noisy places. Later he received a similar replacement pair. In 2020 he was moved to the NHS system and was issued with behind-the-ear aids that were bulkier, less effective and vulnerable to moisture. They were not fitted with Bluetooth, and amplified background noise excessively. He considered private aids but could not justify the cost.

764. As part of his claim, he trialled Widex Moment Sheer 440 aids, with Bluetooth, rechargeable batteries, and app controls. They helped with phone calls and clarity in quiet environments but produced feedback and blocked natural sound, and they still performed poorly in noisy settings. Using interim damages approved during the hearing, he purchased high-end Phonak Virto Infinio aids with custom moulds. These improved clarity in quiet settings but suffered from unreliable Bluetooth connection and charging failures. He continued to have difficulty when a number of people were speaking, with wind noise when out running, and an inability to hear speech from behind.

Leaving the Military

765. In about 2002, he made enquiries about joining the Police and Fire Service, but both rejected him solely due to hearing loss. He remained in HM armed forces for a further 19 years.

766. On 30 September 2021, Mr Lambie was discharged from the services and joined PA Consulting. He told me he had carefully researched possibilities for employment in the private sector before leaving the forces. Having saved up his annual leave and terminal leave, he was able to start working for PA Consulting shortly before his military service ended.

767. It was originally his case that his career there proceeded more slowly than he expected. He explained that promotion requires rotating across assignments, but he would remain longer on each because he needs time to learn people's voices. He struggled to follow conference calls, especially without video or when multiple people speak. Bluetooth dropouts caused him to miss information. Social interactions at work were difficult.

768. His responsibilities at PA Consulting spanned client delivery, commercial assignment management (tracking budgets, reconciliations, contract compliance), and internal contribution to "go-to-market" teams and capability development. His major assignment was to the JSTAR programme (a multi-year national-security programme) where he serves as business change lead.

769. His annual appraisals in 2022–2024 rated him 'Exceeding' requirements, with multiple 'star performer' quarterly reviews. Clients were billed for his services at Principal Consultant level from October 2024; and he achieved substantive promotion to Principal Consultant in April 2025. Reviews commended his leadership, commercial attitude to work, and network building across national security accounts, including organising "knowledge-sharing sessions" and "social cohesion events" for more than 50 PA staff on related assignments.

770. He told me he intends to pursue promotion to Managing Consultant and ultimately partnership. He recognises that progression demands stronger business development capability alongside delivery excellence and internal contribution. He estimates only a handful of Principal Consultants advance, reflecting competition and personal preference. He said: '*I will definitely apply for it. Definitely*,' while acknowledging that he was presently uncertain about his readiness for those demands.

771. Emotionally, he feels embarrassment, fear of seeming incompetent at work, stress, and shame when he mishears people. Despite multiple generations of hearing-aid technology, none restore anything like normal hearing. His hearing loss continues to affect his communication, employment opportunities, household relationships, social participation, and emotional wellbeing. It is a pervasive, lifelong difficulty caused by years of unprotected and inadequately protected military noise exposure.

Samantha Lambie

772. Mr Lambie's wife, Samantha Lambie, described in her statement the strain on their relationship and family life caused by her husband's deafness. She recalls years of arguments caused by misunderstandings, dangers during car journeys, the need to repeat herself constantly, and their children learning to mediate. She explains that he cannot hear the children's voices from another room, cannot handle phone calls privately, and could not hear the babies crying at night, leaving her exhausted. She describes moments of feeling unable to cope, though she emphasises her sympathy for him. Mrs Lambie says her husband withdraws in social settings and becomes isolated.

The Expert Medical Evidence

773. The ENT experts, Mr Silva, who was instructed on behalf of Mr Lambie, and Mr Green for the Defendant, agree that the Claimant's hearing loss is permanent, progressive, and directly impairs his functional hearing.

774. Mr Silva was of the view that *'...his hearing does adversely affect his day-to-day activities.'* and that although he *'...is able to work as a defence and security consultant.' 'It would appear that he struggles directly as a result of his hearing, to undertake his job.'*

775. Prof. Moore estimates that the Claimant's ability to understand speech in background noise has declined by 'at least 90%', based on thresholds at 2 and 4 kHz of 65 dB (left) and 52.5 dB (right). This is contrasted with age-expected thresholds of around 4 dB. Thus, his hearing is approximately 55 dB worse than the norm for his age.

776. It is agreed that Mr Lambie's hearing will deteriorate further, because, as he ages, his noise induced hearing loss will combine with the effects of age associated hearing loss. Mr Silva explained that:

> His noise exposure in early life, will be additive to the progressive effects of age, to give a greater hearing difficulty than would be expected, had he not been exposed to noise. He is therefore likely to experience a greater degree of problems with his hearing later in life than he would have otherwise experienced if not for the noise exposure.

777. In a memorable expression, Prof. King said that Mr Lambie's noise exposure will "*add years to his ears*."

778. The Defendant did not to rely on Mr Green and Prof. Lutman's evidence in Mr Lambie's case, but both agreed in their served reports that Mr Lambie's hearing will deteriorate with age.

779. The experts further agree that hearing aids cannot restore normal hearing. Dr Nassar stated: '*we cannot even begin to restore normal or near normal hearing'*. Even with advanced devices, the Claimant experiences significant functional limitations, including difficulty with speech in noise, sound localisation, and reliance on lip-reading and contextual cues.

Employment Expert Evidence

780. The employment experts, Mr Joseph McKerns for the Claimant and Mr Henry Hailstone for the Defendant, were instructed to prepare a Joint Statement under CPR Part 35.

781. The experts agree the factual background of the Claimant's military career, including his service with the Royal Marines and Royal Navy between 1993 and 2021; his diagnosis with NIHL in 2002; his receipt of hearing aids in 2012; his progression through the ranks to Lieutenant; his selection for promotion to Lieutenant Commander; and his voluntary departure from the Navy in 2021. Both agree that NIHL did not affect his performance or progression as a Combat Intelligence Specialist or Warfare Intelligence Officer.

782. The experts disagree as to whether the Claimant's NIHL limited his career choices. Mr McKerns considers there was an adverse effect, relying on the Claimant's inability to pursue roles such as the SBS or air crew and on his rejection by the police in 2002. Mr Hailstone considers the Claimant's military personnel records show no impact and notes the absence of medical documentation indicating impairment during service. Mr Hailstone also highlights the Claimant's above-average progression and competitive selection for commission.

783. Both experts summarise the medical evidence consistently: the Claimant is likely to continue to struggle with speech in noisy environments; hearing aids help but do not restore normal hearing; he remains employable as a defence/security consultant; and he may qualify as disabled under the Equality Act. They note disagreements between the medical experts Mr Silva and Mr Green over the degree of impairment in daily activities.

784. The experts agree on the concerns expressed by Mr Lambie including difficulty understanding instructions on new assignments, limitations in rotating between assignments, slower expected promotion, and concerns about networking in more senior roles.

785. They agree that the Claimant intends to remain at PA Consulting until age 60; that he has progressed rapidly; and that he seeks long-term advancement to Managing Consultant and Partner. They differ on the likelihood of that progression. Mr McKerns considers the NIHL may significantly impede further advancement, particularly given the demands of client interaction, networking, and future age-related deterioration of hearing. Mr McKerns therefore considers it likely the Claimant will remain at Principal Consultant.

786. Mr Hailstone disagrees. He emphasises the Claimant's strong performance to date, the potential mitigating effect of modern hearing aids, and that PA Consulting derives most of its business from existing clients, meaning large networking events may be less important than the Claimant fears. Mr Hailstone stresses that progression will depend primarily on the Claimant's consulting capability rather than hearing ability. Mr Hailstone identifies three scenarios: remaining at Principal Consultant; progressing to Managing Consultant within 4–6 years; or progressing to Partner within a further 4–6 years.

787. They agree the Claimant's recorded earnings since joining PA Consulting. Mr McKerns sets out broader potential salary ranges, including higher possible maximums, and emphasises the risk that NIHL may prevent progression. Mr Hailstone provides earnings ranges consistent with his three scenarios and notes typical bonus ranges across the consulting sector.

The Competing Arguments

788. Mr Steinberg submits that the Claimant suffers 'severe hearing loss' within JC Guidelines category 5(B)(d)(i), adjusted to £39,226–£60,115. A proposed award of £45,000 reflects the early onset of Mr Lambie's hearing loss at age 21; reliance on hearing aids from 31; progressive deterioration; substantial functional impairment at work and in social life; and ongoing anxiety about future deterioration.

789. On hearing aids, Mr Steinberg submits that the appropriate valuation is £5,000 per replacement cycle, supported by expert evidence from both Mr Hussnain and Dr Nassar, and taking account of recent price increases. Using a multiplier of 4.61 to age 75 yields a future expense of £23,050. With £4,300 already incurred, the total claim is £27,350.

790. Mr Steinberg's central submission concerns the Claimant's status as disabled under the Ogden definition. For this purpose, he argues, impairment must be assessed without hearing aids, in accordance with the DDA 1995 guidance. Mr Steinberg emphasises that the Claimant's functional limitations plainly satisfy each limb: (i) a progressive condition lasting over 12 months; (ii) substantial adverse effect on normal day-to-day activities, including following conversation, hearing speech in noise, and localising sounds; (iii) limitation of the kind and amount of paid work he can undertake.

791. Mr Steinberg argues that the correct approach to a future loss of earnings claim is set out in Ogden Tables A – D. One set of reduction factors is provided which applies to disabled Claimants and another to non-disabled. In the case of a Claimant who has been rendered disabled by his injuries, it is necessary to apply a non-disabled reduction factor to the calculation of predicted <u>but for</u> earnings and a disabled reduction factor to his predicted <u>actual</u> residual earnings. In a case such as the present, where it is not being pleaded that a Claimant will miss out on promotion or have a reduced salary *per se*, the differential will be represented, says Mr Steinberg, by the difference in outcome produced by the two different reduction factors.

792. In calculating the impact of Mr Lambie's disability on his future earning capacity, the respective reduction factors are non-disabled - 0.83 and disabled - 0.53, representing a differential of 30%. Applied to the Claimant's likely future earnings over the rest of his career to 60, Mr Steinberg says that this translates to a shortfall of £332,934.93 in earnings and £37,067.68 in pension contributions, leading to a total of £370,003.

793. Mr Steinberg rejects the Defendant's argument that the Claimant's career success negates disability, arguing that the test is not whether the Claimant can perform his current job, but whether his impairment limits the range of work he can

undertake. He notes the ENT experts' conclusion that the Claimant 'would be unsuitable' for professions requiring very good hearing, including police, fire service, SBS and air crew.

794. He again relies on Barry v MoD, arguing that the Court there affirmed that statistical Ogden methodology, rather than impressionistic reasoning, must be preferred for future earning capacity. He distinguishes Billett v MoD [2015] EWCA Civ 773 as concerning an injury with minimal occupational impact, unlike the present case where NIHL is severe, progressive, and functionally disabling.

795. In the alternative, he seeks a Smith v Manchester award. Given the Claimant's 15 remaining working years, his heavy reliance on verbal communication, and the inevitability of worsening hearing loss, Mr Steinberg submits a three-year award (£192,696) is appropriate.

796. In response Mr Platt accepts that Mr Lambie suffers from NIHL, does not dispute causation, and broadly accepts the orthodox approach to quantification. However, Mr Platt strongly disputes the levels of compensation sought, contending that Mr Lambie has significantly overstated both the severity of symptoms and any consequent occupational disadvantage.

797. Mr Platt argues that Mr Steinberg's attempt to position this case in the bracket for severe tinnitus and NIHL in the Judicial College Guidelines is untenable. The Defendant points out that Mr Lambie has no diagnosis of tinnitus, no hyperacusis, and demonstrates a binaural hearing loss of approximately 40 dB at 1–3 kHz, categorised as borderline mild to moderate. The Defendant highlights that Mr Lambie's personal and professional functioning remains high, and that his recently-acquired, high-end hearing aids provide substantial benefit. On that basis, the Defendant submits that £30,000 is a generous and appropriate award.

798. Mr Platt accepts liability for the cost of top-of-the-range hearing aids. The Defendant previously relied on Dr Nassar's costings but now accepts updated 2025 prices of £4,300 per aid. On that basis, the Defendant calculates a total cost of £25,105.26.

799. On the claim for two Roger microphones, the Defendant argues that only one is reasonably required. Mr Lambie already has a Roger pen microphone for use at one secure worksite. At another site, Tewkesbury, Mr Lambie anticipates being provided another microphone by his employer and could remove it from the premises. The Defendant therefore submits that the reasonable award should be limited to £1,800 for a single microphone.

800. The principal dispute concerns the Claimant's substantial claim of £370,003 for loss of future earnings. Mr Platt rejects the claim in its entirety, describing it as unrealistic and unsupported by the factual evidence.

801. The Defendant's case is that Mr Lambie has demonstrated a highly successful career in both military and civilian spheres. He rose rapidly through the Royal Marines, receiving repeated recommendations for promotion and commissioning. After voluntarily leaving service, he entered a well-remunerated civilian career as a defence-intelligence management consultant. His employer considers him

high-performing, and he has been promoted early. Crucially, the Defendant emphasises that Mr Lambie has had hearing loss throughout his military career, received hearing aids as early as 2011/12, and yet his career trajectory has been consistently upward.

802. The Defendant challenges the credibility and reliability of the Claimant's evidence on disadvantage. For example, Mr Lambie claimed that his promotion to Principal Consultant would be delayed by 'years', yet he was promoted earlier than even his own prediction for his progress on an uninjured basis. His suggestion that earlier bonuses had been reduced due to hearing loss was conceded in cross-examination to be speculative. Likewise, his claim that he remained in long-term project work due to hearing issues was contradicted in oral evidence, where he accepted that his preference to remain within the defence and security sector was due to expertise and personal choice.

803. Mr Platt argues that the Claimant's expert, Mr McKearns, relied too heavily on Mr Lambie's subjective account, lacked analytical rigour, and was contradicted by documentary evidence. In contrast, the Defendant's expert, Mr Hailstone, a former Naval officer with substantial consulting experience, provided what the Defendant describes as balanced and authoritative evidence.

804. The Defendant accepts that Mr Lambie is disabled for the purposes of the Equality Act 2010 but maintains that this does not equate to 'Ogden disability'. Relying on paragraph 90 of the Ogden explanatory notes, the Defendant stresses that disability must be assessed relative to the Claimant's work; the impact of assistive technology must be considered; and residual functional capacity, not unaided capacity, is the correct approach. Mr Platt submits that ignoring the effect of hearing aids would be illogical, particularly as the Claimant seeks substantial sums for such aids.

805. Citing Billett v Ministry of Defence, Mr Platt argues that the Ogden Tables must not be applied mechanistically. If they generate unrealistic outcomes, they should be rejected in favour of a Smith v Manchester award or no award at all. The Defendant draws support from Conner v Bradman, Murphy v MoD, Kennedy and Inglis, which, Mr Platt says, demonstrate the Court's caution in deploying Ogden reductions for disability.

806. The Defendant argues that Mr Lambie's case illustrates why Ogden disabled reduction factors should not be used: he has suffered no past loss; he is thriving professionally; his skills remain in demand; and he works in a secure sector with no evidence of redundancy risk. The Claimant's figure of £370,003 equates to six to seven years' total loss of earnings, which the Defendant characterises as wholly implausible.

807. The Defendant submits that Mr Lambie's NIHL is stable, effectively mitigated by modern hearing technology, and has not impaired his career prospects. It argues that no Ogden-based award is appropriate and that even a modest Smith v Manchester award is unwarranted. In the Defendant's case, the Claimant has suffered no demonstrable employment disadvantage, and only limited special damages are justified.

Discussion

808. Three issues arise and I address them in turn.

PSLA

809. First, damages for PSLA. I set out the relevant part of the JC Guidelines and my views on the general approach to be adopted in chapter 14. The Guidelines are the starting point for the assessment in any individual case. In deciding where the case falls within those Guidelines the Court will have regard to all the circumstances of the case; including the impact of the hearing loss on the individual, the age at which hearing loss occurs and the likelihood and significance of hearing loss occurring in any event as a function of age alone. A Claimant who suffers both NIHL and tinnitus is affected more severely than one who has the one without the other. All assessments involve an exercise of judgement and that involves more than the mechanical application of the Judicial College Guidelines.

810. Over 1, 2 & 3 kHz; the right and left ear thresholds are 38.8 dB and 42.1 dB respectively. Over 1, 2 & 4 kHz, the right and left ear thresholds for Mr Lambie are 34 dB and 42.4 dB respectively. His hearing loss commenced at a very young age, 21, and has had a significant effect on his quality of life. He has been reliant on hearing aids from the age of 31. His hearing will worsen further with age, and he is still only 46 years old. His hearing loss caused substantial functional impairment at work and in his social life; and some ongoing anxiety about future deterioration. Even with good quality hearing aids, his hearing loss continues to have a significant impact on Mr Lambie's home life. However, Mr Lambie has benefitted significantly from hearing aids in the past and will have the very best quality hearing aids in the future. He has not suffered the additional hardship of tinnitus.

811. In my judgment, viewed in the round, Mr Lambie has suffered what should be classed as severe hearing loss within the Judicial College Guidelines. He has no tinnitus. Accordingly, his case falls into category (ii) in the Guidelines – severe NIHL alone. Given all the matters referred to above, however, his case lies at the very top of the category (ii) bracket. I make an award of £39,000 for his pain, suffering and loss of amenity.

Hearing Aids

812. There is almost nothing between the parties on the costs of hearing aids and I am not going to lengthen an already very lengthy judgment by a discussion about £444; in other words, whether the appropriate sum is £27,350 as the Claimant claims or £26,905.26 as the Defendant contend. I make an award in the sum of £27,350, the Claimant's figure, to reflect the possibility that he may need to purchase a second Roger microphone at some stage.

Loss of Future Earnings

813. I turn finally to the largest element of the claim, the claim for £370,000 for loss of future earnings.

814. I begin first by indicating that I found Mr Lambie a deeply impressive witness. He was honest, thoughtful and straight-forward. It was absolutely no surprise to learn how highly he was regarded both in the military and in his present employment. He did not exaggerate his disability; on the contrary he described its negative effects on his life in quiet, unemotional terms. He acknowledged his success in the military and in civilian life in a modest but largely realistic manner. He accepted that, on occasion, he underestimated his own performance and potential, most notably when he accepted that he had achieved promotion at PA Consulting far quicker than he had anticipated. That modest under-assessment of his own ability has some relevance when I come to assess his future prospects.

815. Second, I make clear that where the evidence of the two employment experts differ, I prefer, without hesitation, the evidence of Mr Hailstone. Mr Hailstone was a former Naval officer with a good understanding of Mr Lambie's former career. In addition, he had substantial consulting experience, and he provided what I regard as balanced and authoritative evidence. He was a very impressive witness who, throughout, demonstrated genuine expertise in the subject area and true independence of thought and analysis.

816. By contrast, the Claimant's expert, Mr McKerns, had no experience of the military or the defence sector, no experience of cyber security and no experience of management consulting beyond his own work as a security consultant and a single conversation, the day before he gave evidence, with an unidentified employee of PA Consulting. He based his evidence substantially on Mr Lambie's own account. There appeared to have been little attempt to test or challenge what Mr Lambie said: Mr McKerns simply adopted his account. As Mr Platt fairly observes, Mr McKerns' evidence showed little analytical rigour.

817. Two examples of this will suffice. First, when in the joint report of July 2025, the experts deal with bonus payments Mr McKerns simply recites Mr Lambie's position without any critical analysis. Second, when dealing with Mr Lambie's promotion prospects had he suffered no hearing loss, Mr McKerns records that:

> Absent the index injury Mr Lambie believes he would achieve [promotion to management consultant] within the next 2 to 5 years and then achieve partner prior to age 60 when he intends to retire. Mr Lambie states that there are colleagues within his firm who have also come into the company from the armed forces at a lower rank than him and after 2 years as a principal consultant are developing towards promotion to managing consultant level.

818. Mr McKerns then gives his opinion:

> Absent the index injury, Mr Lambie would be looking to achieve the level of managing consultant within a 2-to-5-year period and then partner level prior to age 60. He states this has been achieved by those in the firm he works with who are working to a similar level that he is. It will be for the court to decide if Mr Lambie would achieve these levels but <u>in my opinion there is nothing in his reviews, absent the index injuries which prevent these goals being achieved</u>… (emphasis added).

819. As Mr Platt puts it in his closing submissions, this "*evidence is simply an almost word-for-word rehearsal of CL's own views about his promotion prospects*."

820. In my judgment, there was no reliable evidence that Mr Lambie's NIHL had any significant impact on his military career. Mr Lambie's progress through the ranks was remarkable; at almost every stage he was marked out as someone fit for promotion and then achieved that promotion and managed the new role with conspicuous success. His choice of career path, in intelligence, was entirely sensible and made possible pursuit of an interesting career both in and after the Armed Forces, together with the proper accommodation of his hearing disability. There is no evidential basis on which I could find that he would have done even better if he had not suffered NIHL, whether in the intelligence Corps or elsewhere in the military.

821. As to his employment after leaving the forces, it is common ground that Mr Lambie joined PA Consulting in June 2021 to work as a consultant in the Defence and Security team. He did so straight from the Armed Forces, with no gap between the two. He was promoted to Senior Consultant in January 2023 and then Principal Consultant in March 2025. It is also common ground that he is competent and ambitious and has been successful in his consulting career despite his NIHL, just as he was in the forces, and that he may be promoted again in the future. There is no claim for past loss of earnings in respect of his military career or his career to date with PA Consulting. He is currently earning what he would have been earning without damaged hearing.

822. On the approach urged in Court by Mr Steinberg, the loss of future earnings claim proceeds on the basis that Mr Lambie will work to 60 at PA Consulting; that he currently earns £72,600 pa gross, excluding bonus and travel payments; that his likely future bonus will amount to 17% of his salary; that his employer will make pension contributions of 8%; that he will be promoted to Managing Consultant in around 2030 and will earn around £115,000 (plus bonus of £19,550) in that role and that he will be promoted to Partner in 2035 and will earn around £150,000 (plus a bonus of around £25,500).

823. In my judgment, that is a realistic assessment of the Claimant's career prospects. It was evident to me that Mr Lambie was a strong and resourceful character. He has been able to maintain a high level of performance in two demanding and stressful employments over a period of some 25 years despite his NIHL. He is now aged 46 and he wants to work until the age of 60. In my view, the overwhelming likelihood is that he will remain at PA Consulting until retirement at 60, as he wishes to do.

824. There are however, three qualifications I would make to that approach. First, it is impossible to predict the future of commercial organisations, or any organisation for that matter, with any great confidence and there remains a risk that for some, currently unpredictable, reason at some, unpredictable, point in the next 14 years, the Claimant may find himself on the labour market. I repeat that I think that unlikely, but it is possible. Second, although I agree that it is likely that Mr Lambie will achieve further promotion despite his hearing difficulties, that cannot be regarded as a certainty. My view is that promotion to managing consultant is likely; promotion to partner is possible, but no more than possible. Third, on the

counter-factual, if Mr Lambie had not suffered hearing loss, I think it very likely that he would have achieved further promotion at PA Consulting. But even that cannot be seen as a certainty. I find as a fact that his hearing loss has reduced his chances of further promotion, but the comparison is not between a certainty and a likelihood but between a greater likelihood and a lesser likelihood.

825. The question is how should these competing risks should be assessed and its financial consequences calculated.

826. In a claim for loss of future earnings in a personal injuries case, the conventional and well-established method is the multiplier-multiplicand approach (see Bullock v Atlas Ward Structures Ltd [2008] EWCA Civ 194). In Ward v Allies and Morrison Architects [2012] EWCA Civ 1287, the Court of Appeal noted:

> It is common ground that the multiplicand/multiplier methodology and the Tables and guidance in the current edition of Ogden should normally be applied when making an award of damages for future loss of earnings, unless the judge really has no alternative.

827. In Kennedy v London Ambulance Service NHS Trust [2016] EWHC (QB) 3145, it was held that the Court should not depart from the multiplier/ multiplicand approach unless, as in Billett (to which I return below), it throws up an obviously unreal approach.

828. The question is whether this is a case where the Court really has no alternative or where the approach is obviously unreal. Mr Platt contends that, if Mr Lambie is disabled, that the multiplier/ multiplicand approach, applying the Ogden Tables, throws up an obviously unreal approach and should not be applied.

829. In order to determine that question it is helpful to consider in a little detail Billett, both at first instance and in the Court of Appeal, and how it has been applied subsequently.

830. In Billett, the Claimant suffered a minor non-freezing cold injury to his feet which had a substantial (i.e. more than minor or trivial) impact on his day-to-day life in cold weather, but which had less effect on his work than it had on his leisure activities. It was held that the problems with his hands were not related to his injury. The Claimant conceded that the only problem he experienced in his job was occasional difficulty pulling down the shutters of his lorry in cold weather, which did not relate to the injury to his feet (i.e. the relevant condition in question). The trial judge's overall conclusion was that the condition qualified as a disability, "but only just".

831. The judge at first instance in Billett was Mr Andrew Edis KC (as he then was), sitting as a deputy judge of the High Court. At [45] of his judgment Mr Edis referred to the Introduction to the Ogden Tables, 7th Edition, published 2011 which contained the following:–

> 17. We have persuaded Dr Victoria Wass to join the Working Party. She has suggested changes to the definition of 'disabled' and also clarified some

> of the language in the Explanatory Notes. We anticipate some further suggestions for amendment in the eighth Edition.
> 18. The Working Party notes that there have been a number of cases in which judges have made significant adjustments to the suggested discount factors. In particular the approach of the trial judges to the calculation of future loss of earnings in *Conner v Bradman* [2007] EWHC 2789 (QB) and *Clarke v Maltby* [2010] EWHC 1201 (QB) has generated some debate. These issues will be discussed in detail when drafting the eighth Edition and consideration given to whether or not the Explanatory Notes need amendment, especially as regards the circumstances in which it might be appropriate to depart from the suggested non-mortality reduction factors and the size of any adjustments that are made. In the meantime, practitioners performing such calculations are referred to the helpful article by Dr Wass, "*Discretion in the Application of the New Ogden Six Multipliers: The Case of Conner v Bradman and Company*", published in JPIL Issue 2/2008 pp 154- 163 which highlights some of the relevant issues.

832. At [46-47] he discussed the views of Dr Wass on the decisions of first instance judges had not applied the reduction factors as set out in the tables

> The Explanatory Notes…therefore expressly permit the Court to depart from a mechanistic application of the Tables in appropriate cases. I have heard submissions in this case concerning the RF, and whether Judges ought to depart from them. I was supplied with two papers written by Dr. Wass since the 7th Edition was published, "Ogden Reduction Factor adjustments since Conner v. Bradman" [2012] JPIL 219 and "Ask the Expert: William Latimer-Sayer Asks Victoria Wass Some Questions about the Practical Application of the Ogden Reduction Factors" [2013] JPIL 36 . The first of these papers identifies a series of cases where judges at first instance in the High Court have altered the RF so as to reduce the size of the award which would otherwise have followed. This is described on page 219 as "judicial interference" and it is apparent that there is a real divergence of view between Dr. Wass and the judiciary about the way in which the Tables should be used. The second article is extremely informative about the RF and contains the following:–
>
> The RFs provide the best available measure of the employment prospects for a typical member of each group. They are accurate as a measure of the group average but they are not likely to be accurate for any individual within that group. Imprecision is an inevitable consequence of scheduled damages. The alternative is an individual assessment by expert in each case.

833. Mr Edis then noted that Dr Wass had been asked why she called the practice of discounting the RFs "unfortunate". He noted her response:

> Apart from the likely injustice associated with under-compensating the Claimant (most adjustments have raised the RF), there is the issue of uncertainty. The purpose of the Ogden Tables, the multiplier/multiplicand formula and the setting of a fixed discount rate is to provide a degree of

> certainty and predictability to the damages calculation and to avoid the need for expert evidence in each case. The approach of judges making routine adjustments without reference to expert evidence in relation to the size of the adjustment, means that it is now difficult to predict the outcome in a given case…."

834. At [48-49], Mr Edis said this:

> The citations from Dr. Wass's 2013 article above seem to me to demonstrate exactly the reasons why a court is unlikely to apply unadjusted RFs to the multiplier, without evaluating the result and adjusting it if it appears necessary to do so. The court is required to fix a figure for compensation in the individual case before it, and the fact that following a Table will produce a figure which is known to be wrong is not answered by the observation that the error is random. This means that if the Tables are applied without adjustment, the right overall figure of damages across all cases will be awarded, but no Claimant will get the correct sum in damages and no Defendant will pay the right sum. If I have misunderstood the passages which I set out above, I apologise but I have not heard from Dr. Wass or any other expert in her field and I must interpret the material before me as best I can.
>
> The alternative to a strict application of the RFs may be "an individual assessment by expert in each case", but that is exactly what I have conducted here. Having heard expert medical and employment evidence and having heard from and assessed the Claimant I would be acting perversely simply to ignore that material. Everyone agrees it is relevant and that I should decide the case on the relevant evidence. The fact of the matter is that this Claimant is employable, and experienced, and suffers from a very mild physical impairment which has some impact on the choice of jobs available to him, but allows him to work as a Heavy Goods Vehicle Driver which is what he wants to do. I accept that it might be significantly harder for him to find such work if he became unemployed and declared his condition on an application form. These facts must be properly reflected.

835. Having considered how the figures in the tables might best be adapted to meet the justice of the particular case he was considering, Mr Edis concluded that he should

> use the multiplier/multiplicand method but that my multiplier will be substantially reduced for contingencies other than mortality to reflect the minor nature of the disability. I consider that in the absence of any other evidence or guidance I should take a mid-point between the not disabled RF of 0.92 and the disabled RF of 0.54, which is 0.73. There is little logic in this approach, except that it gives a figure which appears to me to reflect fully the loss sustained by the Claimant, but to do so in a way which does not obviously overstate that loss. A judicial approach to the assessment of damages involves an exercise of judgment in the individual case being considered. Sometimes statistics give an answer which appears obviously too high, given the picture which emerges in the particular case. Where that happens, the Judge has to make an apparently arbitrary adjustment to that result, or to decline to use the statistical material at all. It appears to me that

> it is preferable to make some use of the Tables and thus to give weight to the data from which they are derived. This means that the Tables have resulted in a higher award than a traditional approach.

836. The Defendants appealed Mr Edis' order, and the Court of Appeal allowed the appeal. Jackson LJ (with whom Patten and McFarlane LJJ agreed) noted at [77] that where

> the Claimant's current rate of earnings is the same as his pre-accident rate, he may still have a claim for loss of future earning capacity. The Claimant is entitled to a lump sum as compensation for the losses which he is likely to suffer in the future by reason of increased difficulty in obtaining or retaining employment.

837. He then referred to the well-known cases of Fairley v John Thompson (Design and Contracting Division) Ltd [1973] 2 Lloyd's Rep 40, Smith v Manchester Corporation (1974) 17 KIR 1 and Moeliker v A. Reyrolle & Co. Ltd [1977] 1WLR 132 and concluded at [57]

> As a matter of convention, a claim for damages on this basis is commonly referred to as a *Smith v Manchester* claim. In practice such awards usually range between six months' and two years' earnings: see Court Awards of Damages for Loss of Future Earnings: an Empirical Study and an Alternative Method of Calculation by R Lewis and others, [2002] Journal of Law and Society, Vol.29, pages 406-435 at 414

838. Jackson LJ then referred to the 6th and 7th editions of the Ogden Tables and the introduction of Tables A, B, C and D. At [94-99] he concluded:

> 94…Some of the bands used in Tables A-D are, of necessity, extremely wide. Disability, as defined in paragraph 35 of the Explanatory Notes, covers a very broad spectrum. In their article Ogden Reduction Factor adjustments since Conner v Bradman: Part 1 [2013] Journal of Personal Injury Law, pages 219-230, the authors point out that the Health and Disability Survey 1996-7 measured severity of disablement on a scale of 1 to 10, where 10 denotes the greatest severity. 42.9% of those classified as disabled fall within categories 1 to 3. 43.9% of those disabled fall within categories 4 to 7. 13.2 % of the disabled population fall within categories 8 to 10.
> 95. There is no evidence as to how the Claimant would be classified within that scale. The natural inference, however, from the judge's findings of fact is that the Claimant would fall towards the bottom of category 1.
> 96. If one applied Ogden Tables A and B in the present case without any adjustment, the result would be an award of about £200,000 for future loss of earning capacity. That is hopelessly unrealistic for the Claimant. He is pursuing his chosen career as lorry driver, with virtually no hindrance from his disability. He secured employment with Framptons within one week of leaving the army. He has strong qualifications for lorry driving and an excellent CV. Furthermore the judge held that the Claimant was "a hard working and capable man, who is likely to be sought after by employers" (judgment paragraph 38 (a)). In order to bring a sense of reality to the

present exercise, it is necessary to make a swingeing increase to the RF shown in Table B (.54). But what should that increase be? Determining an appropriate adjustment to the RF is a matter of broad judgment. In the present case that exercise is no more scientific than the broad brush judgment which the court makes when carrying out a Smith v Manchester assessment.

97. Mr Poole draws attention to a number of articles which argue the case for using Tables A-D, suitably adjusted, in preference to making a Smith v Manchester award. See Ogden Reduction Factor adjustments since Conner v Bradman: Part 1 by Latimer-Sayer and Wass [2012] Journal of Personal Injury Law, pages 219-230 and Ask the expert: William Latimer-Sawyer asks Victoria Wass some questions about the practical application of the Ogden Reduction Factors by Latimer-Sawyer and Wass [2015] Journal of Personal Injury Law, pages 36-45.

98. I accept that in many instances the use of Tables A-D will be a valuable aid to valuing the Claimant's loss of earning capacity. But the present is not such a case. I reach this conclusion for three reasons:

i) Disability covers a broad spectrum. The Claimant is at the outer fringe of that spectrum.

ii) The Claimant's disability affects his ability to pursue his chosen career much less than it affects his activities outside work.

iii) Because of (i) and (ii) in this case there is no rational basis for determining how the reduction factor should be adjusted.

99. The Ogden Working Party acknowledge in their Explanatory Notes that in some instances the Smith v Manchester approach remains appropriate. In my view this is a classic example of such a case. The best that the court can do is to make a broad assessment of the present value of the Claimant's likely future loss as a result of handicap on the labour market, following the guidance given in Smith v Manchester and Moeliker.

839. It is of note that in its judgment in Billett the Court of Appeal (i) re-affirmed the utility and appropriateness of a Smith v Manchester award where the Claimant's current rate of earnings is the same as would have been the case had there been no injury, but there remains a risk of his suffering losses in the future because of increased difficulty in obtaining or retaining employment; (ii) acknowledged that, whilst tables A-D will be valuable in many cases, that will not always be so and did not delimit the latter class of cases; (iii) did not criticise the first instance judge's observations about the difficulties associated with the use of tables A-D; but (iv) allowed the appeal substituting a modest Smith v Manchester award for the judge's much reduced multiplier/multiplicand award.

840. The Court of Appeal's decision in Billett has been considered in a number of subsequent cases. In Murphy v Ministry of Defence [2016] EWHC 3, H.H.J. Coe QC found the Claimant to be disabled but capable of retaining employment for most of the rest of his working life given his determination and employment record since leaving the Armed Forces. The Judge noted that "*The reality here is that the Claimant's particular circumstances and the particular factual matrix are not well suited to the use of the Ogden Tables*." She relied on Billett and made a Smith v Manchester award instead.

841. In Kennedy v London Ambulance Service NHS Trust, the Judge did not apply the raw disabled reduction factor but took a mid-point between the disabled and non-disabled factors because he did not accept that a simple application of the Ogden Tables produced a realistic outcome.

842. In Inglis v Ministry of Defence [2019] EWHC 1153, Peter Marquand sitting as a HCJ, held that the Claimant was "disabled" but declined to accept the raw Ogden Tables and made an upward shift in the reduction factor to 0.7 noting at [217]: "*Leaving the RF at the average would result in overcompensation*".

843. Perhaps of greatest interest is the case of Barry v Ministry of Defence. There, the Claimant had been medically discharged from the Royal Marines at the age of 29 as a result of noise-induced hearing loss. He had served for four years, having signed up for 20. Unable to continue in his chosen career, he secured work as a lorry driver. Although his hearing loss, at the time of trial, was categorised as "mild to moderate", it required him to use hearing aids and would deteriorate as he aged. He sought damages to cover his future loss of earnings.

844. Johnson J held that had the Claimant not been medically discharged it was likely that he would have remained in the Marines for his full 20 years of service. His promotion prospects were aligned to those of an average Marine. Given the significant diminution in his future earning capacity, the conventional multiplier/multiplicand approach had to be used to compensate him fully. His hearing loss had a substantial adverse impact on his day-to-day activities and he was therefore disabled within the meaning of the Disability Discrimination Act 1995 and within the meaning of the Actuarial (Ogden) Tables 8th ed. Section B para.68. Johnson J found that it was not appropriate to disapply the tables and he distinguished the case before him from Billett. He held that the factors that led the Court to disapply the tables in Billett were not present here: the Claimant's case was not at the outer fringe of the spectrum covered by disability, but fell squarely within the examples given in the guidance. He was, however, not pursuing his chosen career, his disability affected the career choices open to him, and his hearing would deteriorate.

845. As to the appropriate adjustment for contingencies other than mortality, it was appropriate to use the "employed" adjustment figure, and the Claimant's educational attainment was at "level 2". That gave a disabled reduction factor of 0.45 and a non-disabled reduction factor of 0.89. Given that the Claimant's hearing loss was currently mild to moderate and was ameliorated by the use of hearing aids, and given that he had (until recently) been in continuous employment since his discharge, there had to be some adjustment to the 0.45 disabled reduction factor. It was not appropriate simply to take the mid-point between the disabled and non-disabled reduction factors. The judge held that the appropriate adjustment had to be based on a broad evaluative judgement which took account of all the relevant circumstances and used the figures in the tables as a guide. Further, the explanatory notes to the tables indicated that any departure from the published mean would usually be modest. The Claimant's drive and determination coupled with the ameliorating effect of hearing-aids could be modelled as broadly equivalent to the advantage gained from a higher educational qualification than he had. Therefore, the features justifying an adjustment were best reflected by using educational level 3 rather than level 2, which gave a reduction factor of 0.56.

846. Mr Steinberg sought to rely on the decision of Whipple LJ on the application to appeal the decision of Johnson J but I accept Mr Platt's submission that it is not appropriate to pray in aid a decision on an application for leave.

847. Barry, like all the cases to which I was referred, turned on its own facts. Compared with the present case, the significant features of Barry were that the Claimant was not able to remain in his chosen career and his disability affected the career choices open to him.

848. When viewing this caselaw in the round, what is noticeable is how often the Courts decline to use the "raw" Ogden Table figures and instead either adopt an adjustment to those figures or revert to a Smith v Manchester award. Johnson J in Barry, applied the tables but used the "employed" adjustment figure with the consequence that the net figure was reduced. In fact, I was not shown a single case where the raw figures were used. As Mr Edis KC said in Billett, none of that is surprising; the judge hearing the case makes "an individual assessment" on each set of facts, based on the expert medical and employment evidence he or she hears and having heard from and assessed the Claimant. To ignore that material would be perverse.

849. The difficulty with using the reduction figures taken from the Ogden Tables is, as Mr Edis said at first instance in Billett, that they provide a measure of the employment prospects for a typical member of the relevant group. They are accurate as a measure of the group average, but they are not likely to be accurate for any individual within that group. The fact that using the Tables will produce the right overall figure of damages across all cases does not justify disregarding the detailed evidence in the particular case.

850. In fact, Mr Steinberg here does not advance a case based solely on the Ogden Tables taken at their most favourable to the Claimant. If he was doing that, he would not make the surprising concession that the right approach is to base the calculation on an assumption that, despite his hearing loss, Mr Lambie will in fact achieve promotion to managing consultant and then partner over the next 10 years. It seems to me likely that he has taken the reasonable forensic course of not seeking to argue that the Ogden formula should be applied against the figures for the higher grades for fear of making this head of claim too great to be remotely credible.

851. It is the task of the judge on a claim such as this to carry out the appropriate individual evaluative judgement based on the evidence before the Court. In my view, where the Court has a detailed picture of the Claimant, the way his injuries have impacted on his ability to work in the past, the evidence as to his current and future prospects, and the likely impact of his disabilities on those prospects, then statistical information about the average performance of a class of persons of which he forms part may well provide a useful starting point or cross check. But it will not be common for those statistics wholly to displace judicial evaluation of the individual case. To borrow a submission of Mr Steinberg's from a different context (the "baseline correction" debate at [267] above), "*using population averages to downplay individual…findings risks treating a Claimant as a statistical abstraction rather than applying clinical judgment to individual evidence*".

852. In my view, Mr Lambie is disabled within the meaning of the Disability Discrimination Act 1995 but his case is far from the average, even an "adjusted" average. His case is not one where it is appropriate to apply the Ogden Tables, 8th Ed. Unlike, for example, Mr Barry, Mr Lambie has been able to pursue his chosen career throughout and will, in all probability, be able to do so until retirement. His disability has not, thus far, affected the career choices open to him or the earnings he has been able to make. His hearing loss is serious and progressive with age but, as things currently stand, he is not suffering any loss of earnings, nor will he if, as seems likely, he remains in his current employment until retirement.

853. To award a man in Mr Lambie's position the sort of sum proposed by Mr Steinberg would, in my judgment, be unconscionable. His current net take home pay is about £60,000. Including bonus but excluding pension, the sum claimed for loss of future earning amounts to more than six times his current annual net salary. And that for a man who has not been unemployed for a single day since he was 18, who is in steady employment with a reputable employer, whose work in under no threat and in respect of which there is no evidence of any future likely threat, who is highly valued by his current employers and who wishes to stay in his current job until retirement.

854. What does require recognition, however, is first that were Mr Lambie to find himself on the open labour market, for whatever reason, then, despite his enviable employment record and the doubtless excellent references he would obtain from past employers, his NIHL would put him at a significant disadvantage in seeking alternative work. And second, the fact that his chances of achieving the two promotions that might have been available to him had he not suffered hearing loss are reduced. These are, in my view, uncertain considerations not capable of precise or even approximate calculation by a multiplicand-multiplier basis.

855. In my judgment, this is not an appropriate case for an award based either on an Odgen Table disabled reduction factor or based on a traditional multiplier/multiplicand basis. The appropriate remedy is an award of damages for loss of earning capacity, under the Smith v Manchester principle. In my view, an award equivalent to 12 months at his current earning rate would be appropriate. I will hear submissions from counsel on that calculation but if one takes his current gross salary of £72,600, add 17% to reflect likely bonus, deduct tax and NIC, add 8% to reflect his employers pension contribution, one is left with an annual figure of £64,800. It follows that the figure I allow for loss of earnings capacity is £64,800.

856. In those circumstances, I value Mr Lambie's claim as follows

- General Damages for PSLA £19,000;
- Interest on general damages at 2% pa
- Hearing aids £27,350
- Loss of earning capacity £64,800

857. That figure falls to be reduced by 10% to reflect the application of the Matrix.

Chapter 19 - Mr Jack Craggs

Introduction

858. Mr Craggs' case is the second of the two lead cases which remained for decision. In his case, liability was admitted subject to a 25% discount on application of the Matrix agreement. In his case there has been no admission of causation; in other words, no admission that he suffered any NIHL or tinnitus as a result of his exposure to noise during military service.

859. Accordingly, the issues in dispute were causation of any hearing loss or tinnitus, and if any such were proved, the appropriate award of general damages for pain, suffering and loss of amenity (PSLA), hearing aid costs and tinnitus equipment and treatment.

860. In summary, the Claimant invited the Court to conclude that:

- The appropriate award for PSLA was £30,000;
- The award for hearing aids should be £29,999; and
- The award for tinnitus equipment and treatment should be £1,260.

861. The Defendant's primary case is that no award under any of these heads is appropriate. Its secondary case is that, if causation is proved, then the appropriate awards are:

- £17,500 for PSLA;
- £446 for tinnitus treatment; but
- Nothing is recoverable for hearing aids (under the principle in Woodrup v Nicol) because Mr Craggs is unlikely to buy them; his trial showed only slight benefit; experts disagree on benefit; and he still has not sought NHS aids.

The Evidence

862. Mr Craggs was born on 31 May 1979 and so, like Mr Lambie, is now aged 46.

Mr Craggs' Account

863. In his three witness statements, Mr Craggs describes the relevant features of his history. He says he enlisted in the British Army on 18 August 1998, initially training as a Royal Military policeman before transferring to complete infantry training. He joined the 2nd Battalion Royal Green Jackets, and was deployed to Kosovo and Bosnia. He reports that he was never informed that any of his hearing-test results during service were abnormal and that the culture of the army discouraged complaints. After his Kosovo deployment, he experienced a static ringing noise in both ears at night, lasting around 30 minutes and occurring mainly in quiet environments. At the time, he did not understand the significance of this.

864. After discharge in 2002, he entered various civilian roles before joining the scaffolding trade in 2005. He said tinnitus gradually became more noticeable once he moved into a quieter civilian environment. In 2008, he became employed as an

offshore scaffolder, a role involving exposure to loud plant machinery which was subject to strict hearing-protection requirements, including double protection in high-noise areas. He said he did not initially associate difficulties, such as needing to turn the television up louder, with hearing loss.

865. Over time, Mr Craggs reports, he experienced persistent tinnitus and increasing difficulty understanding speech, particularly in environments with background noise such as restaurants, pubs, supermarkets, and airports. He relied on background noise to mask tinnitus, often sleeping with the television on. He describes feelings of embarrassment, reduced social confidence, social withdrawal, frustration in conversations, and impact on family and romantic relationships. He worried increasingly about his hearing, fearing deteriorations would be picked up in employment medicals and expressing concerns about future decline and employability.

866. In his second statement, Mr Craggs details the workplace hearing tests carried out in 2021, 2023 and 2025. He reports variability in booth soundproofing and recounts a malfunction delaying the April 2025 test. He admits that due to fear of losing his job, he sometimes pressed the audiogram button more frequently than appropriate, believing it might help him pass the hearing test. He recognised this made results unreliable but told me that his colleagues had acted similarly.

867. As part of his claim, Mr Craggs undertook trials of Phonak Infinio and Widex 440 hearing aids for 10 days each. He wore them throughout the day, except while showering or sleeping. He found both comfortable, but experienced intrusive hissing with the Widex devices, which he felt replaced tinnitus with another noise. By contrast, the Phonak aids significantly improved clarity of sound, improved television listening, and effectively masked his tinnitus, improving his mood and day-to-day functioning. Upon removal at night, he said, tinnitus immediately returned. He was unable to trial either device at work due to restrictions on lithium batteries on oil rigs. He expressed a desire to purchase the Phonak devices for personal use.

868. Across the three statements, the chronological progression alleged is clear: onset of symptoms during military service; gradual worsening in early civilian life; increasing impact on daily functioning, social life and emotional wellbeing; heightening anxiety about job security due to hearing tests; and finally, evidence from hearing-aid trials indicating meaningful relief from tinnitus and improved quality of hearing.

869. Mr Platt's cross-examination of Mr Craggs unfolded as a sustained inquiry into the accuracy, consistency and reliability of his recollection of events spanning more than two decades, beginning with his entry into the Army in 1998 and continuing through his long period of civilian employment in the scaffolding and offshore oil and gas sectors. It was apparent that the purpose of the questioning was two-fold: to test the factual foundations of his claim to noise-induced hearing loss and tinnitus allegedly arising during military service, and to examine the credibility of his later accounts, including in occupational health records, medico-legal consultations, and his own witness statements.

870. Mr Craggs confirmed that he joined the Army at 19, after an earlier failed attempt due to a foot condition, and that he served until January 2002 with the 2nd Battalion, Royal Green Jackets, including deployments to Kosovo and Bosnia. He agreed that throughout his service he underwent routine audiometric testing, each of which recorded normal hearing, consistently graded, using the army grading system, H1H1. He accepted that at no stage did he report any problems with his hearing, despite being a frequent attendee at the medical centre for other conditions during training and deployment. When asked why, if he was experiencing hearing loss or troubling tinnitus, he made no complaint, he said that the culture of military life discouraged such reporting, that he did not at the time appreciate the significance of his symptoms, and that he did not wish to jeopardise his status as a fit soldier.

871. When questioned about his tinnitus, he was unable to provide a consistent account as to whether this occurred every night, whether it affected his sleep, or how long such a pattern continued. When confronted with Mr Green's note that he had stated his hearing loss was first noticed after leaving service, Mr Craggs denied saying this and suggested that the consultant Mr Green must have recorded him incorrectly. He insisted that his hearing difficulties began in service but conceded that his recollection of details was poor after the passage of so many years.

872. Attention then shifted to his civilian employment. After leaving the Army, he held a series of short-term jobs before entering the scaffolding trade, eventually moving offshore to work for RBG Limited in 2008 and transferring to Bilfinger Salamis by TUPE around 2010. He was shown his CV, completed in 2012, and accepted that that document overstated the duration of his Army service by more than a year and omitted all of his early civilian employment. He initially suggested this might have been a typographical error but later accepted that his CV was "messed up", blaming poor drafting skills and the assistance of a friend. He denied deliberately extending his army service to make himself appear more experienced. There was no satisfactory explanation of how the inaccuracies occurred.

873. Mr Platt then questioned him about his history of hearing difficulties during his many years offshore. The working environment, he agreed, was extremely noisy. He was required to use hearing protection at all times in operational areas, either ear plugs or Peltor ear defenders. He accepted that his witness statement inaccurately claimed that Peltor defenders were "always" required, conceding that in practice ear plugs were more commonly worn except in the places where double protection was mandated. Occupational noise assessments from 2012 and 2017 were put to him: both showed that he was wearing only ear plugs, contradicting his statement.

874. The occupational health records formed a significant part of the challenge to his credibility. The earliest disclosed offshore medical examination from October 2009 recorded "normal hearing" in both ears. Tests in 2011, 2015, 2017, and 2019 similarly placed him in category 1 hearing. When asked why, if he had suffered serious hearing difficulties for years, none of these examinations revealed them, he replied that hearing tests caused him great anxiety. He described entering the audiometric booth fearful that a poor result might cost him his job, leading him to press the response button repeatedly, sometimes without being sure whether he had heard a tone. He said that this behaviour may have distorted the test results.

875. He further admitted that he had not been truthful in the 2017 occupational health questionnaire, when he stated that his hearing was “good”, that he had no difficulty with background noise, and that he did not need to turn the TV up louder than others. He said he did so because he feared that disclosing symptoms might cause him to fail his medical and lose his employment. He repeated this explanation for inconsistent entries in the 2019 questionnaire, although the 2019 form did record some difficulties, such as trouble hearing in background noise and the presence of ringing in his ears.

876. He was unable to provide a clear explanation about the change in account between 2017 and 2019, denying that it had anything to do with his having instructed solicitors in 2018 to bring this claim, or having served a statement of case in 2019. I pressed him on whether he was knowingly misleading his employer, and ultimately, he accepted that he had deliberately given incorrect answers to avoid employment consequences. He did not accept that this reflected adversely on the truthfulness of his claim, but acknowledged the seriousness of misleading occupational health assessors in safety-critical employment.

877. In respect of his tinnitus, he gave evidence that it was constant, bilateral, and intrusive, significantly affecting his mood and ability to relax, particularly during downtime offshore when the environment was quieter. He maintained that it had worsened over the years and that it frequently delayed his ability to fall asleep. He was challenged with the account recorded by Mr Zeitoun in 2021, in which he was noted as saying that tinnitus did not disturb his sleep. He attempted to reconcile this by drawing a distinction between “sleep disturbance” in the sense of waking during the night, which he said did not happen, and difficulty falling asleep, which he said did. In my judgment, that was pure sophistry by Mr Craggs.

878. He accepted that he had never sought medical attention through his GP or NHS audiology services at any stage, despite claiming to have suffered from these symptoms since 2000. When asked why, he said he had not appreciated the seriousness of the condition and had simply “got on with it”.

879. His evidence concerning hearing aids was also tested. Despite claiming in his witness statement that he needed hearing aids to continue in his employment, he had never attempted to obtain any, either privately or through the NHS, until a trial arranged during the litigation. He accepted that he was aware that hearing aids existed and that they assist hearing but said he had not understood their potential benefit to him until he tried them. The trial involved two sets of hearing aids over twenty days. He stated that the first pair significantly improved his hearing clarity and masked his tinnitus so effectively that he hardly noticed it at all during daytime use. However, the audiologist’s post-trial assessment recorded only a “slight” improvement in tinnitus and moderate improvement in other areas, such as television volume and hearing his mother. When this discrepancy was put to him, he was unable to explain it, suggesting that there may have been miscommunication. He accepted that after the trial he made no effort to obtain hearing aids independently.

880. Mr Platt’s cross-examination concluded with a focus on whether his account of the timing and severity of symptoms was reliable. Numerous inconsistencies were put to him: within his witness statements, between those statements and the

medical evidence, between the medical evidence and the occupational health records, and within the occupational records themselves. He frequently answered that he did not know, could not remember, or could not provide a date. He repeatedly referred to being overwhelmed, confused, or anxious. While he continued to assert that his hearing loss originated in military service, he was unable to provide a consistent narrative of its onset or progression. The defence suggested that his recollection may have been influenced by the litigation process, particularly by conversations with colleagues about claims and material encountered online. He denied this.

881. Mr Craggs maintained that although he had on occasions provided incorrect information, this arose out of fear and confusion rather than dishonesty, and that his core account, of gradual deterioration in hearing beginning with military noise exposure, remained truthful.

Mrs Condit

882. Mrs Elizabeth Condit, born on 7 April 1953, is the mother of the Claimant. She gave evidence in support of her son's claim. She told me that she has been in regular and close contact with him throughout his life. Jack lived with her until he joined the Army at 19, and again for a short time upon discharge in 2002. She continues to see him during his periods at home from offshore work, usually once or twice every three-week rotation, and they communicate almost daily by phone or text.

883. She told me that Jack's father was also in the Army, and that inspired Jack to join up. She recalls his excitement at being accepted. He spoke fondly of his service, but later left the Army to be with his fiancée and to pursue a career in the police. His relationship ended, and his application to the police was unsuccessful.

884. Mrs Condit told me that her son had no hearing difficulties prior to joining the Army. She remembers him first complaining of a static ringing noise in his ears after returning from deployment in Kosovo, although she cannot recall the precise date. The noise occurred particularly at night. She recalls him mentioning this new symptom during that period. She noticed that when Jack returned home after service, he began to increase the television volume. At the time, she did not think much of it, attributing it perhaps to habit.

885. Over the years (the number of which were not specified), Mrs Condit said she had observed a steady decline in her son's hearing. The television volume is now significantly louder than she can tolerate; she once asked him to reduce it but now refrains, understanding that he cannot hear it otherwise. He listens to audio on his phone at maximum volume and reports being unable to hear it if turned down. She describes frequent communication problems. With the television on, Jack is unable to hear her at all; she must first reduce the volume before speaking. She often needs to repeat herself, which can be frustrating for both of them. If she speaks to him from another room, even with the door open, he cannot hear. He responds with "what?" and becomes frustrated. She must often move into the same room to have a functional conversation.

886. Her son, she told me, often complains to her of tinnitus at night. He struggles to lie in silence due to static ringing in his ears. To sleep, he now keeps the television on to mask the noise. She has witnessed him experiencing tinnitus episodes during visits, becoming visibly frustrated and upset.

887. Mrs Condit is aware that Jack has been advised to obtain hearing aids and tinnitus treatment. She notes that he appears worried about needing hearing aids at a relatively young age, particularly visible ones, and concerned about compatibility with his offshore work. She believes that less visible aids would reduce his anxiety and enable him to benefit from them.

888. When cross-examined, Mrs Condit acknowledged that she and her son had spoken about the case on multiple occasions over the years, particularly as he would stay with her regularly when visiting the UK. However, she rejected the proposition that her understanding of events was solely derived from her son's account. She maintained that she had personally observed changes in his hearing over time.

889. She described occasions when she had encouraged her son to seek medical advice and confirmed that she had raised the subject of hearing aids with him within the last five or six years. She explained that he had been reluctant to pursue hearing aids because he believed wearing them might affect his ability to work.

890. Throughout her evidence, Mrs Condit repeatedly acknowledged the limits of her memory regarding precise dates but was clear and consistent in her account that her son's tinnitus began after Kosovo and his symptoms had worsened over many years.

Expert Evidence

891. I heard evidence on Mr Craggs' case from Mr Green and Mr Zeitoun, ENT surgeons, Professors Moore and Lutman on auditory perception, Mr Hussnain and Dr Nassar on hearing aids, and Dr Mahmood on speech in noise testing.

892. Although the experts approached their assessments differently, Mr Zeitoun having conducted a direct clinical examination and commissioned audiometry in December 2021 and Mr Green relying primarily on a later telephone consultation, they considered the same suite of audiograms. These included those taken during the Claimant's military service between 1997 and 2001, an occupational health audiogram performed in 2017, and two medicolegal audiograms dated 2021 and 2024.

893. At a broad level, the experts agree that the Claimant complains of hearing loss and that the audiograms from 2017, 2021 and 2024 exhibit features consistent with noise-induced hearing loss in the left ear, most notably a notch at 4 kHz with recovery at 8 kHz. They also agree that the military audiograms cannot determine whether NIHL was present at discharge because they did not record thresholds at 8 kHz. Both experts accept that noise-induced hearing loss, where present, is permanent and that orthodox opinion holds that noise damage does not progress after exposure ends. Additionally, they agree that the Claimant experiences tinnitus, which they attribute to noise exposure during his military service.

894. Despite these areas of concurrence, the experts diverge significantly on several material issues. The first concerns whether the Claimant suffers from noise-induced hearing loss attributable to his military service. Mr Zeitoun considers that the later audiograms, particularly from 2017 onwards, display deep notches, mostly in the left ear, characteristic of NIHL and that the military audiograms are unreliable. He points to repeated symbol errors, the absence of 8 kHz testing, and the inherent limitations of screening audiometry. In his view, these factors mean that early indicators of NIHL may have been missed. Mr Green, by contrast, accepts that the later audiograms demonstrate features consistent with NIHL, but emphasises that these features emerged only after military service had ended, and that the final military audiogram in 2001 shows no NIHL at the key diagnostic frequencies of 3 and 4 kHz.

895. A further point of disagreement arises when they consider whether NIHL was present at the time of discharge. Mr Zeitoun argues that the military audiograms, owing to their deficiencies, cannot reliably exclude the presence of NIHL. Mr Green is firmly of the view that these audiograms demonstrate normal thresholds at the critical frequencies and thus exclude NIHL at discharge.

896. The experts also part company on potential alternative causes of any hearing loss. Mr Zeitoun considers that NIHL combined with age-related change are the only plausible explanations. Mr Green, however, says that the deterioration occurred after exposure ceased and therefore cannot be attributed to noise.

897. There is a similar divide on the quantification of NIHL. Mr Zeitoun carries out detailed calculations employing various recognised methods and concludes that the Claimant has sustained a modest but measurable degree of NIHL in the left ear. Mr Green does not offer quantification because he does not accept that there is any service-related NIHL.

898. The experts differ further on the interpretation of the Claimant's reported difficulties hearing speech, particularly in noise. Mr Zeitoun believes that the Claimant's subjective difficulties exceed what would be expected from the audiometric findings and that speech-in-noise testing supports the Claimant's account. Mr Green, however, relies on the interpretation of Prof. Lutman, who concluded that the Claimant performed better than average in these tests.

899. On prognosis, Mr Zeitoun raises the possibility that, if NIHL is accepted, there may be an acceleration of age-related loss over time owing to underlying cochlear damage. Mr Green rejects this idea and aligns with the orthodox view that noise-related deterioration does not progress after exposure ends.

900. Although both experts accept that the Claimant has tinnitus linked to noise exposure, they differ on whether it is associated with NIHL. Mr Zeitoun links the tinnitus to the presence of NIHL, whereas Mr Green separates the two, attributing tinnitus to noise exposure at the time but not the NIHL.

901. They also take different positions on the impact of any impairment on daily life. Mr Zeitoun considers that the Claimant's hearing loss and tinnitus adversely affect his day-to-day functioning, especially in environments with background noise. Mr Green maintains that the audiometric results do not explain the Claimant's

reported functional limitations and therefore does not accept that these symptoms would have the impact described.

902. In their joint statement Prof. Moore and Prof. Lutman confirmed that they had considered the reports of medical experts Mr Zeitoun and Mr Green, including an addendum by Mr Zeitoun (10 April 2025), alongside evidence from hearing aid dispenser Mr Hussnain and speech testing by Dr Mahmood.

903. They both note that the Claimant's reported symptoms include difficulty hearing in background noise and the need to increase television volume. He also complained of constant bilateral tinnitus, sometimes disturbing sleep.

904. They agree that two medicolegal audiograms (2021 and 2024) display results within or just above the conventionally normal range (≤20 dB HL). A left-ear notch or bulge is present at 3–6 kHz. Occupational health audiograms showed no systematic deterioration during service, although the experts differ as to their reliability. Speech testing by Dr Mahmood yielded an SNR loss of 2.5 dB (QuickSIN) and 4 dB (BKB), though the experts diverge on the validity of these findings.

905. The medical experts disagree on causation. Mr Green attributes no hearing loss or tinnitus to service; Mr Zeitoun considers tinnitus noise-induced and quantifies noise-induced hearing loss (NIHL) using both LCB and M-NIHL methods. Prof. Moore, using the Moore–Lowe–Cox (2022) method and the 2024 audiogram, produces NIHL estimates at several frequency averages.

906. A central diagnostic issue is whether noise exposure can accelerate hearing loss progression after exposure ceases. The experts disagree fundamentally. I have already expressed my conclusions about that issue in chapter 10 above and those conclusions apply here. They agree, however, that the Claimant's thresholds are now mildly elevated such that he can detect most practically important sounds.

907. Prof. Lutman identifies the key issue as whether deterioration between service discharge (2002) and the 2021 audiogram can be attributed to noise exposure ending in 2002. He doubts this, asserting insufficient scientific evidence for delayed or latent noise effects from realistic exposures. He considers it implausible that four years of exposure produced no measurable effect by 2001, yet apparent NIHL emerges two decades later.

908. He cites a recent 2025 JAMA Otolaryngology study (Dillard et al.) showing only minimal differences in hearing deterioration associated with historic noise exposure and considers these insufficient to explain the Claimant's threshold changes.

909. Regarding speech testing, Prof. Lutman maintains that the QuickSIN and BKB results reported by Dr Mahmood contain methodological inconsistencies. He identifies contradictions between primary and supplementary reports, discrepancies in materials used, unexplained differences between practice and test performance, and scoring irregularities. He concludes the practice lists, showing substantially better performance, should be preferred as the truer indicator of ability and that the formal test results are unreliable.

910. It is his opinion that the Claimant performs better than the average young normal-hearing listener on corrected speech-in-noise metrics and that hearing aids would be unlikely to help and may hinder. Hearing aids might assist tinnitus, though he doubts benefits would outweigh disadvantages. He sees no adverse impact on employability.

911. Prof. Moore maintains that noise exposure during military service can accelerate later progression of hearing loss where little or no measurable loss is present at service end, thus applicable to all frequencies for Mr Craggs. He disputes reliance on occupational health audiograms, citing their recognised unreliability.

912. He rejects Prof. Lutman's criticisms of the speech tests, asserting that practice sheets were mistakenly provided initially but the formal QuickSIN and BKB-SIN sheets, later supplied, show that Dr Mahmood conducted both tests correctly and used appropriate scoring. He considers the speech tests valid, indicating genuine functional hearing difficulty in noise, consistent with the Claimant's symptoms.

913. Citing recent research, Prof. Moore asserts that many individuals with near-normal audiograms but self-reported difficulties benefit from hearing aids and that U.S. veterans with similar profiles increasingly and successfully use them. He concludes the Claimant is likely to benefit from hearing aids due to directional microphone and noise-reduction systems improving speech perception in noise.

914. Mr Khiyam Hussnain, instructed on behalf of the Claimant, and Dr Gregory Nassar, instructed on behalf of the Defendant, were asked to prepare a joint report on three issues: whether the Claimant would be assisted by hearing aids; if so, what type; and whether, in relation to tinnitus, the Claimant would benefit from any further aids or treatment.

915. In that joint report, both experts recognised the Claimant's reported hearing difficulties, though their conclusions differ in degree. As set out in their joint report, Mr Hussnain considers that whilst any benefit may ultimately prove limited, a hearing aid trial was the most reliable way to determine whether the Claimant would derive measurable assistance, particularly in challenging listening environments. He did not consider offshore work constraints to preclude onshore benefit. Dr Nassar, by contrast, took the view that the Claimant was unlikely to obtain any meaningful advantage from hearing aids at present, considering that any potential benefit would be minimal. Nevertheless, the experts agreed that as matters stand there was insufficient justification to recommend hearing aids outright.

916. Because Dr Nassar does not consider hearing aids appropriate, he offered no recommendation concerning specific devices or accessories. Mr Hussnain, said that if a trial were undertaken, modern devices capable of supporting complex listening situations, such as Phonak Infinio Sphere hearing aids, might be appropriate, with additional accessories such as television connectors considered only if the Claimant continued to struggle in those contexts. The overall agreed position was that device-specific recommendations could not be made unless and until a hearing aid trial established that hearing aids would be of benefit.

917. Turning to tinnitus, both experts recognised that this is a subjective condition and that supportive interventions might be beneficial. They agree that tinnitus counselling and informational support could assist the Claimant. However, they differed on the likely extent of sessions required. Dr Nassar considered that a maximum of three sessions should suffice to provide basic education and coping strategies. Mr Hussnain, however, explained that some individuals require a more extended and tailored approach depending on their response, and that up to seven sessions may be appropriate in some cases.

918. Mr Hussnain and Dr Nassar also gave oral evidence. Mr Hussnain confirmed his instructions to recommend an appropriate set of hearing aids that might benefit Mr Craggs. His understanding was that he was required not merely to recommend specific devices, but to assess whether a recommendation was necessary at all. His assessment drew upon various materials, including an interview with the Claimant, the 2021 audiogram, the reports of Mr Zeitoun, and commentary on speech-in-noise testing.

919. He accepted that the history recorded by him from the Claimant differed in some respects from the history given to Mr Zeitoun, including the extent of difficulties hearing speech in background noise and the effect of tinnitus on sleep. He did not explore these discrepancies with the Claimant, explaining that he took what the Claimant reported at face value.

920. Addressing the 2021 audiogram, he agreed that the Claimant exhibited only a very mild high-frequency hearing loss, and that such a presentation would not typically lead to a recommendation for hearing aids. However, he emphasised that clinical decision-making combines audiometric thresholds with the patient's subjective account of hearing difficulties. Because the Claimant described difficulties in group conversations, in background noise, and ongoing tinnitus, he considered that a trial of hearing aids was reasonable. He relied on NICE guidance recommending bilateral aids for patients with both tinnitus and any degree of hearing loss.

921. He acknowledged that his report did not record his discussion with the Claimant regarding readiness to wear aids, although he maintained that such discussions had occurred. He also explained the potential role of hearing aids in alleviating tinnitus but accepted that he could not predict the degree of benefit in any given case.

922. He agreed that, in the joint statement with Dr Nassar, both experts accepted that any benefit from hearing aids at this stage might be "minimal". He maintained that a trial remained justified because even limited amplification could offer meaningful subjective benefit.

923. His addendum report addressed the 2024 (Holt Hearing) audiogram, which he considered broadly consistent with earlier testing. He stated that, based on the Claimant's reported difficulties and mild hearing loss, he remained inclined to recommend a trial of newer Phonak Infinio devices. He accepted that, according to what the Claimant told Dr Nassar, hearing difficulties occurred only "on occasion". He stated that the wording was ambiguous but that it nonetheless indicated some degree of difficulty in background noise.

924. When shown the hearing-aid trial report, he accepted its limitations: it did not specify the hearing-aid model used, included no data logging, and contained no objective functional testing such as QuickSIN or BKB-SIN. Nonetheless, he explained that objective testing is only one part of evaluating benefit and that subjective experience remains clinically significant.

925. He agreed that tinnitus improvement recorded during the trial was only slight, and that the report's strongest recorded benefit, improved communication with a partner, was of limited relevance given the Claimant lives alone.

926. When asked directly, he accepted that if the Court were to conclude that the Claimant's account of his hearing difficulties was unreliable, then, given the mildness of the hearing loss, there would be little basis on which to recommend hearing aids. He reiterated, however, that his recommendation was founded on the combination of the audiogram and the Claimant's reported symptoms.

927. Dr Nassar's oral evidence addressed four principal themes: (1) the provenance and reliability of audiometric testing; (2) the interpretation of hearing thresholds and the criteria for recommending hearing aids; (3) his opinion on the Claimant's hearing difficulties at the time of his initial assessment; and (4) his reaction to more recent evidence, including later audiograms and the Claimant's own description of a hearing-aid trial.

928. I say straightaway that I found Dr Nassar a very impressive witness. He was straight-forward and sensible. He made concessions where appropriate and expressed himself in a moderate and considered manner.

929. Dr Nassar was taken to an audiogram dated 2 April 2025, which he regarded as unreliable. He identified several deficiencies: the form was incomplete; the date of birth and name were inaccurate; and the recorded symbols showed that required masking procedures had not been undertaken in accordance with British Society of Audiology (BSA) standards. These failings suggested the results were "very poor" in reliability.

930. He considered a separate audiogram of 4 April 2025. Although this appeared more internally consistent, he noted that the audiometer had not been calibrated for over two years. In professional practice, he explained, equipment exceeding its calibration period, even by one day, would render the results unusable. Accordingly, he regarded this audiogram as unreliable. Notwithstanding these concerns, he accepted that, taken at face value, the April 2025 figures appeared worse than the CERA-validated audiogram from August 2024. Any such deterioration of 10–15 dB at key frequencies, he said, would ordinarily be noticeable to a patient.

931. Dr Nassar explained that the decision to fit hearing aids is based on two elements of equal importance: (a) the pure-tone audiogram; and (b) the patient's self-reported difficulties. He noted that clinical experience demonstrates significant variability: some individuals with near-normal thresholds report genuine benefit, whereas others with measurable hearing loss may not benefit at all.

932. He agreed that NICE guidance does not stipulate a threshold level at which aids must be provided and emphasises patient-reported difficulty. He also confirmed that the only reliable way to assess potential benefit is through a properly conducted hearing-aid trial.

933. Dr Nassar explained that during his telephone consultation with the Claimant on 4 February 2025, the Claimant reported only occasional difficulty in background noise. On that account, combined with the August 2024 audiogram, he concluded that hearing aids were not indicated "at this current stage". In his view, the Claimant's hearing presentation at that time did not justify a trial. He contrasted that report with the Claimant's much more severe description of difficulties given in oral evidence at trial, which he characterised as "drastically different".

934. Dr Nassar had not been provided with data from the recent hearing-aid trial, but he heard the Claimant's account in Court. He regarded a ten-day trial period as short, noting that in both NHS and private practice he would expect a trial of four to six weeks to allow acclimatisation. Nonetheless, he accepted that if a patient self-reported significant benefit, whether or not the audiogram predicted it, an audiologist would not usually withdraw the aids.

935. He found it surprising that the Claimant expressed dissatisfaction with the Widex aids (which seemed to have been set to emit a masking noise) yet reported benefit from the Phonak aids, but accepted the Claimant's account at face value. He agreed that, in light of the later audiometric figures and the Claimant's more serious description of his hearing difficulties, it was reasonable that a hearing-aid trial was attempted.

936. Dr Nassar maintained his view that, as at February 2025 and on the basis of the August 2024 audiogram, hearing aids were not clinically indicated. However, he accepted that later events, namely the April 2025 audiometry (if accurate), the Claimant's trial of hearing aids, and the Claimant's more severe account of his symptoms at trial, could justify a hearing-aid trial and could explain why the Claimant might perceive benefit.

937. Finally, I heard the results of speech in noise testing conducted by Dr Mahmood.

938. Dr Mahmood is a consultant audiologist and clinical scientist at Great Ormond Street Hospital, where he had practised for 18 years. His duties encompassed adult and paediatric audiology, teaching at UCL, regular performance of speech-in-noise tests, oversight of complex auditory processing clinics, and supervision/training of colleagues. He confirmed routine use of BKB, BKB-SIN and QuickSIN methods for over 15 years.

939. There was an error in his original report; he had said that the testing was done "in clinic." He corrected this in his supplementary report, stating it was a home visit. He explained that the error arose from templated text, apologised, and said he realised the mistake only after discussing the matter with solicitors.

940. He accepted he had no independent recollection of travelling to or testing in the Claimant's home and reconstructed the location from administrative records,

including absence of clinic-hire payments. He accepted this reconstruction was partly speculative.

941. Dr Mahmood was cross-examined following late disclosure of additional materials relating to his speech-in-noise testing methods, including a redacted report from another case and QuickSIN/BKB-SIN manuals. He explained his private practice and involvement with EFM Hearing Ltd, which received instructions via medico-legal agencies. In 2022 he completed between 50 and 100 medico-legal reports, consistent with previous years, and undertook hearing-aid fittings both NHS and privately. He accepted his workload was intense.

942. He described the distinction between practice/familiarisation sheets and formal testing sheets. Practice sheets are used to acclimatise patients, may contain repeated items, and are not valid for scoring. Formal testing uses strict protocols: QuickSIN uses 6 sentences (SNR 25→0); BKB-SIN uses the formula 23.5 minus correct answers.

943. He explained his habit of writing on practice sheets ensures consistency and avoids distracting patients once formal scoring begins.

944. Mr Platt repeatedly pressed him on his inability to recall routes, travel, or the physical circumstances of the test. He accepted he did not remember these details and relied on inference. Mr Platt suggested a systemic flaw because of similar documentation problems in another case. Dr Mahmood denied this, attributing errors to administrative oversight and reaffirming the validity of formal test results.

945. He accepted several errors, including attaching wrong sheets and mis-stating location, apologised, and explained they were inadvertent.

946. Mr Platt questioned whether practice sheets could confuse interpretation and whether long familiarisation periods were appropriate. Dr Mahmood defended his methods as clinically standard and reiterated he relied exclusively on formal scores.

947. The cross-examination highlighted administrative inaccuracies and memory limitations but also demonstrated Dr Mahmood's longstanding expertise in speech-in-noise testing. He maintained the formal results were valid and clinically sound, though he accepted that aspects of his documentation were deficient.

The Competing Submissions

948. The written and oral submissions on Mr Craggs' case are particularly lengthy. Mr Steinberg's written closing submissions on this one case ran to 190 paragraphs plus attachments; Mr Platt's totalled 212 paragraphs plus attachments. What follows is only the briefest of summaries. I address the central elements of the competing submissions in the *discussion* section below.

949. In short summary, Mr Steinberg submits that Mr Craggs sustained extensive unprotected exposure to hazardous military noise during his 3 years in the army. He had normal hearing on entry and now suffers from noise-induced tinnitus and

hearing loss attributable to that exposure. He submits that the evidence shows that the tinnitus began following his deployment to Kosovo in 1999–2000. Mr Craggs and his mother gave consistent evidence of early onset tinnitus. Both ENT experts (Mr Zeitoun and Mr Green) agreed that the tinnitus is noise-induced and attributable to military service. The defence suggestion of spontaneous tinnitus or psychological causation should be rejected on the basis that such explanations were expressly ruled out by the ENT experts.

950. Mr Steinberg says that it is common ground that Mr Craggs now has hearing loss with features typical of noise damage. Close analysis of the audiometry, he argues, shows that the changes began in service. In the alternative, if the features emerged later, the hearing loss is still attributable to noise exposure because military noise depleted the cochlear reserve. He argues that there is no credible alternative cause: occupational noise after the army was insufficient, hearing protection was consistently used offshore, and idiopathic loss is unlikely in a young adult, especially when asymmetric.

951. Mr Steinberg submits that the 1997, 1998 and 2001 military audiograms are unreliable due to incomplete data, calibration issues, and implausible threshold improvements. The 2017 audiogram is accepted by all sides as reliable, particularly the 8 kHz thresholds. On the refined audiometric table, if the unreliable 2001 audiogram is disregarded, the service audiograms show early changes consistent with NIHL.

952. The asymmetrical hearing loss (left worse than right) accords with the head-shadow effect from firing right-shouldered weapons. Experts accept this pattern is typical of NIHL and would be rare in idiopathic loss. Tinnitus is also a supportive marker of auditory system injury.

953. Mr Steinberg accepts that Mr Craggs' recollection of onset of symptoms is imperfect but argues that the credible account of early, subtle symptoms is supported by his mother's observations and by the ENT experts' explanation that early mild losses commonly go unreported. Occupational health records from 2013 corroborate early hearing problems attributed to Army service.

954. He says that Dr Mahmood's formal BKB-SIN and QuickSIN tests show mild but real impairment. He invites the Court to reject the allegations that the results derived from practice sheets. Mr Steinberg relies on the supporting documentation from GOSH protocols confirming that correct procedure was followed and that only formal scoresheets produce valid SNR-loss scores.

955. He says that tinnitus is properly graded as moderate (by Mr Green). It has persisted since early adulthood and causes sleep disturbance. Based on the Judicial College Guidelines, an award of £30,000 is claimed.

956. Mr Steinberg submits that NIHL affects both ears (left meeting diagnostic criteria; right contributing). He argues that, due to asymmetry, binaural calculations may under-represent disability. Hearing aids have provided clear benefit during a trial, including masking tinnitus. Costs of £29,999 are claimed.

957. He seeks £500 for tinnitus counselling (reflecting the mid-point between the experts' views) and £760 for tinnitus masking equipment.

958. In response, Mr Platt argues that Mr Craggs was an unreliable historian: his evidence was confused, inconsistent, and often reconstructed rather than recalled. He highlights multiple contradictions; inconsistent accounts of the onset of hearing loss and tinnitus; failure to seek medical assistance despite claiming severe symptoms; contradictory evidence regarding occupational hearing tests; attempts to manipulate occupational hearing results; and discrepancies in his CV. Mr Platt submits that Mr Craggs' lay evidence should not be relied upon in any respect that is disputed.

959. He says that Mr Craggs' mother was not independent, her recollection was influenced by discussions with him. She exhibited gaps in memory and inconsistencies. Mr Platt submits that her evidence does not provide reliable corroboration of Mr Craggs' claims.

960. Mr Platt accepts that recent medicolegal audiograms (2021, 2024) show left-sided features compatible with NIHL, but stresses that such features are not pathognomonic; there is no right-ear NIHL; and there is no evidence linking these later features to military service.

961. The Defendant's core argument is that the military audiograms (1997–2001) are consistent, reliable, and show no systematic deterioration. Mr Green and Prof. Lutman state that taken as a series, the audiograms are highly consistent; there is no progressive change at 3 or 4 kHz in the left ear; the 1999 confusion about ear-symbol orientation does not affect the consistency; the 2001 audiogram is not "too good to be true" but consistent with expected youthful thresholds; and the Claimant's hypothetical reconstructions using assumed 8 kHz values are artificial and should be rejected because the military audiograms show no NIHL patterns during service. Mr Platt argues that Mr Craggs cannot succeed unless he proves post-exposure progression caused by military noise.

962. Mr Platt submits that the Claimant's experts advanced contradictory and shifting rationales: sometimes relying on progression, sometimes on rejecting the military audiograms. He emphasises Prof. Moore's equivocation; Mr Zeitoun's swings in approach; the lack of consistent evidence of post-service abnormal progression; unreliability of the two 2025 audiograms; and the absence of any measurable progression between 2021 and 2024.

963. Mr Platt cites Prof. Lutman's evidence that cochlear reserve is quickly exhausted, typically during noise exposure or by early adulthood, and cannot explain a decades-delayed, military-noise-driven deterioration.

964. Mr Platt contends that Mr Craggs' claimed service-era symptoms lack documentary support. He argues that Mr Craggs' statements are inconsistent, he attended medical centres frequently for minor ailments but never for ear issues, tinnitus reports were inconsistent between experts and tinnitus cannot prove NIHL, given that tinnitus can occur without NIHL.

965. Mr Platt highlights Mr Green's view that attribution to service requires a reliable temporal link, which depends entirely on Mr Craggs' credibility. If Mr Craggs' account is rejected, there is no basis to find noise-induced tinnitus. Mr Platt submits that the speech-in-noise evidence is wholly unreliable: the wrong sheets were attached; the report contained multiple admitted errors; the testing environment was unverified; practice sheets were inexplicably scored; BKB and BKB-SIN tests were muddled; and handwriting suggests calculations were made on the wrong sheets. He argues that no weight can be placed on Dr Mahmood's results.

966. Mr Platt argues that synaptopathy cannot assist Mr Craggs: it cannot be proven without post-mortem testing, and no proxy measures exist for Mr Craggs.

Discussion

967. A number of my conclusions on the generic issues are directly relevant to Mr Craggs case, notably my conclusion in chapter 6 that military audiograms can properly be taken into account in reaching a diagnosis, particularly when they are part of a series; my conclusion in chapter 8 that the diagnostic method to be preferred is rM-NIHL, Prof. Moore's revised Military NIHL method; my conclusions on latency and acceleration in chapter 10; on cochlear synaptopathy in chapter 11; and on tinnitus in chapter 12.

968. Four issues arise for consideration, namely (i) the weight that can be placed on Mr Craggs' own evidence; (ii) the other evidence of hearing loss and the causation of such hearing loss; (iii) the cause, onset, persistence and severity of tinnitus; and (iv) the need for hearing aids and tinnitus counselling and masking equipment

(i) The Weight to Be Attached to Mr Craggs' Own Evidence

969. Mr Craggs was a very unsatisfactory witness. I found wholly unconvincing the answers he gave on the following topics: the start of his hearing loss, his military hearing tests, his hearing tests with Bilfinger and his response to his alleged symptoms. In these regards, I largely accept the submissions of Mr Platt. I deal with each issue in turn.

970. To Mr Zeitoun, Mr Craggs reported that he suffered decreased hearing during his army service. To Mr Green, on 14 August 2024, one month before he signed his first statement on 16 September 2024, he said that he, "*was unsure when he first noticed his hearing loss but thinks it was <u>after his military service</u>*" (emphasis added). In cross-examination, Mr Craggs said that he thought Mr Green had made a mistake, but, as Mr Platt correctly submits, Mr Green was not challenged on that in his cross-examination.

971. At [89] in his first witness statement, Mr Craggs said that, at about the time he returned from Kosovo, "*it did not occur to (him) that (he) had a significant problem with (his) hearing. (He) had regular hearing tests during his time in the military and (he) was never told there were any issues*". He was asked whether the hearing loss he allegedly experienced during his military service was "*sufficiently noticeable that you could pick it up, in terms of your interactions with people or dealing with crowded situations*". He replied, "*I can't remember*". I

asked him why, in that case, he had said in his statement that it did not occur to him that he had a significant problem with his hearing during his service. He replied, "*Because it said, "significant problem", I probably just -- I don't know*". I asked again why his statement said what it did; he replied "*Maybe – I don't know*". He was asked again what he had noticed during his time in the infantry and he replied, "*I'd say it goes back to the ringing.*" He was pressed as to whether he was saying that he was struggling with his hearing as early as 2000/2002. He said he could not remember.

972. There are no references in any military records to suggest that Mr Craggs reported tinnitus or hearing loss. He accepted he saw no-one about these conditions at the time. That was so despite the fact that he was a fairly regular visitor to the medical centre with comparatively minor issues.

973. He was taken to his 3 December 2001 military audiogram. It was pointed out that, in response to a question "*Any current ENT problems*", the box marked 'no' had been ticked. It was put to him that he must have been asked about any hearing problems and that he denied them at the time. His response was "*I thought I had problems with my hearing, but nobody else told me I did".*

974. That was a somewhat opaque answer, and I pressed him on it. He said that he deliberately gave a false answer when asked because he was worried about being discharged from the Army:

> *MR JUSTICE GARNHAM: … is the position that you were asked about your hearing, you did have a problem with your hearing, and you thought, "I tell you what, I'm not going to tell them because I might end up getting discharged".*
>
> *A. That would be fair to say, my Lord, yes.*

975. In that response it seemed to me that Mr Craggs was grasping at a proffered answer in an attempt to escape an obvious difficulty. But then, asked by Mr Platt to confirm what he had told the Court, he responded, "*At that time, I don't know why I gave that answer*". It was then put to him that he could not have been concerned about a medical discharge in December 2001 because he had already given notice to leave the Army some months earlier. He answered, "*I'm not entirely sure why I answered the question like that*". In my view, that answer was deliberately disingenuous. Mr Craggs was not doing his best to assist me but was ducking and diving in an attempt to avoid answering difficult questions.

976. Mr Craggs was asked at some length about audiometric tests he had whilst employed by Bilfinger. He said in cross-examination that he had <u>not</u> tried to cheat his Bilfinger hearing tests:

> *Q. You didn't, for instance, again try and – it may sound pejorative – cheat the audiogram, you didn't try to give different answers to that which was correct and truthful?*
> *A. To essentially cheat it? No.*

977. But as Mr Platt points out, eventually he shifted his ground and admitted that he had been attempting to cheat his Bilfinger hearing tests:

> *MR JUSTICE GARNHAM: You're deliberately trying to get a better result for your hearing, aren't you?*
> *A. Yes, through – yeah, as I've mentioned before, my Lord.*

978. Mr Craggs emphasised on a number of occasions that he was worried about keeping his job. But I received no evidence to corroborate the suggestion that his job would be at risk if his hearing level were to be downgraded.

979. He was taken to his August 2017 audiometry questionnaire in which he had described his hearing as 'good', had denied needing the TV or radio louder than the rest of his family, and had denied difficulty hearing in a lot of background noise. He was asked if he had answered truthfully; he replied, "*you don't mean to misinform*". But he then conceded, in effect, that he was saying that he did mean to misinform and that he deliberately gave incorrect answers because he was frightened of losing his job.

980. In his 2019 questionnaires he had acknowledged some hearing difficulties. He was asked why he had been able to mention these difficulties in 2019 but not in 2017. The following exchange then took place:

> *MR JUSTICE GARNHAM: Why do you mention these problems in 2019 but don't mention them in 2017?*
> *A. I don't know, my Lord. Maybe I've filled it in -- maybe it's a possibility that I've filled it in incorrectly or -- I can't remember, my Lord.*
> *MR JUSTICE GARNHAM: You first spoke to solicitors about claiming in 2018. Has that got anything to do with this change in answer?*
> *A. No, my Lord.*
> *MR JUSTICE GARNHAM: No?*
> *A. I'm getting a bit overwhelmed, my Lord. I'm getting a bit –*
> *MR JUSTICE GARNHAM: I want you to take your time, but this is important, so think about your answer to me, please. I am asking you if you can explain the different answers you give in 2017 and 2019.*
> *A. At this time, I can't explain it correctly, my Lord.*

981. The result of all this is that I feel unable to place any weight on Mr Craggs' evidence generally unless it is corroborated by other evidence. I have to look elsewhere to determine what hearing loss, if any, he suffered.

(ii) The Other Evidence of Hearing Loss and its Cause

982. There are five preliminary points to be made.

983. First, there is no dispute that Mr Craggs now has hearing loss. Mr Green accepted this in both his written and oral evidence and the fact of some hearing loss in recent years has been objectively verified by CERA validation. Mr Green described the significance of CERA testing in his generic report:

> In the United Kingdom, cortical electric audiometry (CERA) has been accepted by the Courts when objective testing to determine thresholds is

required. This is the most frequently used objective testing method in current UK medicolegal practice.

984. Second, Mr Craggs' unchallenged evidence as to his activities and experiences in the military establishes that he was exposed to significant noise, and the Defendant has admitted that that noise was sufficient "to be capable of causing NIHL".

985. The third question is whether there is any alternative exposure which might account for the Claimant's hearing loss. For a time, it seemed to me that there was an alternative candidate for the cause of the noise damage in the employment Mr Craggs obtained after leaving the armed forces. Scaffolding, both on shore and offshore, is a very noisy occupation and it was apparent that Mr Craggs has been involved in those trades for many years.

986. However, the clear effect of the evidence is that his employers were, very properly, conscientious in insisting on their staff using proper ear protection. And, on balance, I accept that Mr Craggs routinely wore that protection. In truth, there was no hard evidence that he did not. Mr Green, the Defendant's ENT expert, accepted the position. In his oral evidence, he rejected the idea that Mr Craggs' scaffolding work would have produced anywhere near the level of noise required to cause a risk of damage to his hearing. He said:

> There will be some noise with clanking and stuff, but I think, if I recall, Mr Craggs said that wasn't an issue because of the way he did things. I appreciate there may be some noise around him. But it's different from working in a factory.

987. I asked Mr Green about the possibility that Mr Craggs' hearing loss had been caused by exposure to noise on the oil rigs. The following exchange took place:

> *MR JUSTICE GARNHAM: Sorry, may I ask a question on that?... It couldn't be caused by some other exposure to noise in the period between 2002 and 2017? Say, for example (if) he never used hearing ... protection.*
> *A. Yes.*
> *MR JUSTICE GARNHAM: Could that do this?*
> *A. If there was enough noise exposure, then yes, that -- in that scenario, that could happen.*
> *MR JUSTICE GARNHAM: I'll make it clear, I'm not making any such finding at the moment at all.*
> *A. Audiometric features of noise can be caused by -- would be caused by all sources of excess noise.*
> *MR STEINBERG: But there is no suggestion in your report -- because that's something that you would need to consider carefully, isn't it, because it is not just saying there's some noise elsewhere, it has to be a significant level. That was the purpose of me showing you the Noise Immission Levels under R2.*
> *A. Yes.*
> *Q. So you don't consider that in your report because you don't consider it to be an option?*
> *A. No, I don't. I don't.*

988. Fourth, the current picture is of asymmetric hearing loss. As Mr Zeitoun put it:

> The audiograms of 02.08.2017, 04.12.2021 and 21.08.2024 show diagnostic indicators of the effect of noise on hearing, which is noted even by eyeballing the graphs of the tests. There are deep notches seen in the audiograms, mainly in the left ear. The pattern is with asymmetry, with greater hearing loss in the left ear than the right…

989. It is common ground that a pattern of asymmetric hearing loss is typical in military cases. As Mr Zeitoun went on to say: that pattern of asymmetric hearing loss is "in keeping with individuals who used firearms with the stock placed on the right shoulder".

990. Fifth, there was no evidence of Mr Craggs having any conditions which might predispose him to hearing loss. Mr Green said in his report on Mr Craggs and in his oral evidence that Mr Craggs had no personal or family history of hearing loss or tinnitus, his general health was good, there was no evidence of ear disease, and he had no history of noisy hobbies.

991. Taken together, these five conclusions on the evidence – that Mr Craggs was not predisposed to hearing loss, that he was exposed to relevant noise in the army, that he now has asymmetric hearing loss, greater on the left than the right, and that there is no evidence pointing to an alternative causative factor – are all entirely consistent with the Claimant's case that he suffers from NIHL caused as a result of his service in the army. But they do not prove that causative link. That requires audiometric evidence that meets the requirements of rM-NIHL.

992. In the course of very lengthy evidence on this (and related) question, Mr Steinberg produced and referred to what came to be called "The Steinberg Table", a useful aide memoire setting out all the audiogram results for Mr Craggs for the period 08.09.97 to 04.04.25. I reproduce it below:

		0.5kHz	**1kHz**	**2kHz**	**3kHz**	**4kHz**	**6kHz**	**8kHz**
Right	08.09.97	5	5	5	5	5	15	/
	13.07.98	5	5	0	0	5	5	/
	28.09.99	0	0	10	10	10	10	/
	01.11.00	10	10	5	5	10	20	/
	03.12.01	0	0	0	0	0	0	/
	02.08.17	5	-5	5	-5	10	0	0
	16.06.21	20	15	15	10	15	15	/
	04.12.21	10	10	10	5	5	15	20
	11.05.23	10	5	5	-5	15	15	/
	21.08.24	10	10	10	5	15	20	15
	02.04.25	10	15	25	35	40	25	15
	04.04.25	10	15	20	15	30	35	20

		0.5kH	1kHz	2kHz	3kHz	4kHz	6kHz	8kHz
Left	08.09.97	10	5	5	0	10	20	10
	13.07.98	5	0	5	5	10	15	/
	28.09.99	5	5	0	0	5	10	/
	01.11.00	10	5	5	5	10	15	/
	03.12.01	5	0	0	0	0	10	/
	02.08.17	5	10	5	15	15	10	-5
	16.06.21	10	20	15	20	20	20	/
	04.12.21	15	10	5	20	20	25	10
	11.05.23	5	10	5	15	5	20	/
	21.08.24	10	10	10	25	20	25	10
	02.04.25	15	15	20	30	35	30	25
	04.04.25	15	15	20	25	25	30	30

993. Two important and related issues arise in relation to these results. First, are all the audiograms noted here reliable or should some be disregarded? And second, considering the whole series of reliable audiograms, do they meet the requirements of rM-NIHL? Do they point to there having been NIHL beginning during the period when Mr Craggs was serving in the army, or is Mr Craggs' current hearing loss idiopathic?

994. It is common ground that the medico-legal audiograms (4 December 2021 and 21 August 2024) are likely to be accurate and that the first post-service audiogram of 2 August 2017 was also likely to be accurate, especially at 8 kHz.

995. Mr Steinberg says that no weight can be placed on the threshold values recorded in the first two military audiograms (September 1997 and 13 July 1998), or the final military audiogram dated 3 December 2001, and that the two audiograms in 2025, should be disregarded. In contrast, Mr Platt says that the military audiograms are generally consistent with one another. They should be taken as a series and, fundamentally, should be deemed reliable. They do not show evidence of systematic progression, such as would be caused by NIHL, especially in the left ear (i.e. the ear that can be 'diagnosed' with NIHL some 20 years later).

996. Although Mr Green concluded that the 02.08.2017, 04.12.2021 and 21.08.2024 audiograms show diagnostic indicators of the effect of noise, it was his opinion that those features only developed after Mr Craggs' service in the army and therefore could not be related to it.

997. Mr Steinberg says that there is a fundamental problem with the first two military audiograms (8 September 1997 and 13 July 1998) in that the relevant audiograms are unavailable: the recorded values are based on second-hand recitations of the results. He points out that there is no information about essential matters such as calibration, the conditions of the tests, ambient noise, or even who took them (the signature boxes on the results summary sheets are unsigned).

998. I reject the submission that the absence of the original audiograms should result in the Court disregarding the recorded results. Certainly, these deficiencies mean the Court should view the results with caution and only accept them if they are part of a consistent pattern, but I see no warrant for treating them as if they did

not exist. The Court should have regard to the best available evidence, which is the second-hand recitation of the results in Mr Green's report.

999. Mr Steinberg says that at least one of the audiograms is demonstrably wrong. There is a single 8 kHz reading (in the left ear in 1997), which is 10 dB. He says that must be incorrect: the equivalent 8 kHz reading in the reliable 2017 audiogram was -5 dB, which would represent a 15 dB improvement (beyond the margin of error) over two decades. I accept the evidence of Mr Green, and the submission of Mr Steinberg, that that would not be possible. But, as Mr Steinberg also points out, that result is barely legible and was scribbled out on the summary sheet. In my view, the most obvious explanation for it being crossed out is that it was recognised as being wrong at the time.

1000. Mr Steinberg is also very critical of the final military audiogram dated 3 December 2001. This was part of Mr Craggs' release medical assessment. He says that there are clear indications that the tester on this occasion was not a trained audiologist: crosses were used for both ears when the symbols for left and right are conventionally different; the calibration date was left blank; and there is no evidence that the audiometer was within calibration.

1001. More fundamentally, argues Mr Steinberg, there was an unexplained improvement, beyond the margin of error, of 15 dB at 6 kHz in the right ear. And in the right ear there was "a sweep of zeroes", zero was recorded at every frequency from 0.5 to 6 kHz. In the left ear there were zeroes from 1 to 4 kHz.

1002. There are two difficulties with this argument. First, it is the results in the left, not the right, ear that are critical. It is in the left ear that NIHL can be diagnosed in the post 2017 audiograms.

1003. Second, Mr Green was asked whether he had ever seen an audiogram similar to the 2001 one before. He replied, "*Yes, in young people*" When challenged that this looked "*a bit suspicious*", he responded:

> *A. No. As I said, people in their early 20s will commonly have thresholds at 0. Frequently, I will see thresholds at minus as well, mins 5/minus 10. So young people have better hearing, as has been discussed before. As we age, we lose our hearing. But, for someone in their early 20s, hearing around zero is not unusual*".
> *Q. You misunderstand. I don't mean a zero reading is unusual. I mean a uniformity of 0 at every level?*
> *A. I don't think it is particularly unusual in this age group. Now, if it was a 40-year-old man or 45 or older, then I would say yes. But, otherwise, I don't think it is particularly unusual.*

1004. I accept that evidence and reject the submission that the 2001 audiogram should be disregarded.

1005. Mr Steinberg advances a further, novel, argument. He proposes that the Court should adopt a new version of his table created by filling in 8 kHz readings for the military audiograms using the value from the 2017 audiogram on the basis that hearing at 8 kHz does not improve over time.

1006. I reject that highly artificial argument. It would only have potential significance if the 2001 audiogram was ignored and for the reasons just stated, I do not accept that the 2001 audiogram should be ignored.

1007. It follows that I prefer Mr Platt's argument on this crucial issue. The military audiograms are broadly consistent and, as a series, are reliable. They provide no support for a conclusion that Mr Craggs sustained NIHL in the army. Furthermore, I see no sound basis for reconstructing those results or making assumptions about what the missing records at 8 kHz would be, in order to make them fit Mr Steinberg's thesis. In my view, the audiograms shown in the "Steinberg table" when read as a whole do not satisfy the requirements of rM-NIHL and certainly do not show the sort of progression that would be expected if Mr Craggs suffered NIHL during his military service.

1008. Furthermore, for the reasons I set out when dealing with his evidence, I regard Mr Craggs' assertions of hearing loss during, or in the years immediately after his army service, as wholly unpersuasive. Having watched and listened carefully to him, I regret to say that I am firmly of the view that he was not a witness of truth on whom I could rely. His hesitancy, caution, inconsistency, confusion and changes of mind did not come across as the product of nervousness or tiredness or poor memory, but of evasion and calculation.

1009. On this topic I did not find the evidence of Mrs Condit of any great assistance. I have no doubt that she was trying to give me a truthful account and, as I explain below, her evidence on the issue of her son's tinnitus was helpful. But she was perfectly frank in acknowledging that she could not be precise about dates. There is no doubt that Mr Craggs' hearing has deteriorated and I am sure that for the last several years he has needed the volume on the TV turned up to an increasing degree. But I do not accept that that was the position either during Mr Craggs' military service or in the years immediately after it.

1010. I regard it as inconceivable that if, as he now alleges, Mr Craggs was experiencing worsening hearing loss over a period of a decade and a half, or more, after leaving the army he would never have reported it or sought assistance for it. It follows that I do not accept that he suffered any significant hearing difficulties in that period.

1011. In my view, when he ticked the "no" box at the time of the 3 December 2001 military audiogram, he was telling the truth; given that he was in the process of leaving the army he would have no reason to lie. It may well be that by 2017 he was beginning to experience some hearing difficulties but in my view his denials of needing the TV or radio louder than the rest of his family or struggling to hear when there was a lot of ambient noise was accurate. All of that is consistent with my reading of the audiograms; this was a man whose hearing began to deteriorate long after he left the military. Certainly, it is clear, and agreed by both sides that audiometry since August 2017, supports a diagnosis of NIHL in the left ear, whether considered under the rM-NIHL or CLB guidelines. But there is no such support before then.

1012. I have already rejected, in chapter 10, the suggestion that such damage could be latent; certainly, in my view, it is far-fetched to conclude that 2 or 3 years of noise exposure could have produced no evidence of NIHL at the time or for perhaps 15 years thereafter but still explain NIHL discovered even later.

1013. I accept that it is unusual for idiopathic hearing loss to affect only one ear in the absence of an identified medical condition causing such loss. Prof. Moore said that asymmetry

> increases the likelihood that they have military noise-induced hearing loss, particularly because, if you had a so-called idiopathic hearing loss, a hearing loss arising from some other cause, that would, more often than not, be similar in the two ears. Asymmetric cases are rarer and usually there would be some specific medical condition associated with that.

1014. Mr Zeitoun said that the audiograms of 02.08.2017, 04.12.2021 and 21.08.2024 show diagnostic indicators of the effect of noise on hearing, (which he said can be seen even by "eyeballing" the graphs of the tests). There are deep notches seen in the audiograms, mainly in the left ear. The pattern is asymmetric, with greater hearing loss in the left ear than the right. That, it is agreed, is in keeping with individuals who used firearms with the stock placed on the right shoulder.

1015. Mr Zeitoun said that if the Court rejects the opinion that Mr Craggs has NIHL, then

> on the balance of probability, the Claimant has an unusual pattern of age associated hearing loss or an idiopathic cause of hearing loss that specifically targets frequencies sensitive to noise at a greater rate in the left ear than the right.

1016. That captures my conclusion on the point.

1017. In my judgment, Mr Craggs has failed to establish, on the balance of probabilities, that his late discovered hearing loss was caused during his military service. Idiopathic hearing loss, hearing loss without identifiable cause, may be rare but it does occur and it cannot be discounted in favour of presumed military-NIHL in the absence of supporting audiograms. That is all the more the case where, as here, there is no clear, coherent or credible account of hearing loss by the person allegedly suffering it.

1018. It follows, that I reject the claim that the Defendant is responsible for the Claimant's hearing loss.

1019. That being so, it is not necessary for me to go on to consider the extent or nature of the current hearing loss. As a result, I am saved the burden of trying to interrogate and understand the extraordinary evidence from Dr Mahmood which I have touched on above.

1020. On any view, Dr Mahmood made a number of serious mistakes in the preparation and presentation of his evidence relating to Mr Craggs' ability to hear speech in noisy conditions. He made appropriate apologies to the Court for those mistakes, and I do not propose saying anything further about his evidence.

(iii) Tinnitus – Onset, Cause, Persistence, Intensity

1021. I have accepted Mr Platt's submission about the reliability of Mr Craggs' evidence in relation to hearing loss. However, I reject his submissions that Mr Craggs' account of the onset and duration of tinnitus is unreliable.

1022. The one subject upon which Mr Craggs' gave consistent and credible evidence was his tinnitus. He has always said that he developed tinnitus during service after returning from Kosovo between November 1999 and March 2000. During that deployment in Kosovo, his Platoon discharged hundreds of rounds from an illicit arsenal of weapons. They were not wearing any hearing protection. In his oral evidence, Mr Craggs described experiencing temporary ringing in his ears thereafter. This developed into a permanent condition, which he described in his witness statement in the following way:

> I started to notice a static ringing noise coming on at night times in both of my ears. It would only come at night times when I was trying to get to sleep and would usually last around 30 minutes before going away. I did not know what this could be at the time because it only happened in the evenings and went away after a short while.

1023. Mr Craggs was clear and consistent in telling me that his tinnitus began during his military service, that it affected him every single night and that it continued for "*a prolonged period*", in effect for the rest of his service and beyond.

1024. His evidence on the subject was, to some extent at least, confirmed by his mother. Mrs Condit could obviously not speak to the occurrence of tinnitus which, for Mr Craggs, is an entirely subjective condition. But she could speak to his contemporaneous complaint of tinnitus. And she did so. As noted above, she told me that she remembers him complaining of a static ringing noise in his ears after returning from Kosovo, that he often complained to her of tinnitus at night, that he reported struggling to lie in silence due to static ringing in his ears, that in order to sleep, he kept the television on to mask the noise and that she has witnessed him becoming visibly frustrated and upset because of tinnitus.

1025. It was agreed by the ENT experts that "the tinnitus is as a result of noise exposure during the Claimant's military service." No alternative cause for the condition has been identified or postulated and neither ENT expert suggests this was a case of spontaneous onset of the condition. It follows that I accept that Mr Craggs suffered tinnitus as a result of his exposure to noise in the military and that he has suffered from that condition from the time of his military service to date.

1026. As to the severity of that condition, however, I am less confident in placing any reliance on Mr Craggs' descriptions. He described his current situation in his first witness statement of September 2024:

> My tinnitus affects my downtime, and I feel like it is getting worse. I always need some form of noise in the background to try and drown out the static noise. I will usually put the TV on or some music. It also keeps me awake at night, which is frustrating. It can take between one or two hours for me

to get off to sleep at night because of the noise in my ears. I have to keep my TV on to try and drown this out.

1027. However, there are significant discrepancies in Mr Craggs' description of his tinnitus. When Mr Zeitoun saw him, the only hearing issue recorded related to the volume on the television. It was said that his tinnitus "*Does not disturb his sleep but he is conscious of the noise*". He had also told Dr Nassar that, "*During the day and in his normal routine he is not aware of his tinnitus*" and in cross-examination he stated, "*In my working environment, there's a lot of noise, so it drowns it*".

1028. I conclude that Mr Craggs developed tinnitus during military service, as a result of exposure to noise during that service, that that condition worsened somewhat over the following years to a state where he was conscious of it when in quiet surroundings and at night. I accept it does on occasions make it harder for him to get to sleep. That condition will be permanent.

1029. Mr Zeitoun graded Mr Craggs tinnitus as 'mild to moderate'. Mr Green graded it as 'moderate'. The grading scale by McCombe et al. sets out the categories of tinnitus as follows

> Grade 2 – mild… Easily masked by environmental sounds and easily forgotten with activities. May occasionally interfere with sleep but not daily activities.
>
> Grade 3 – moderate… May be noticed, even in the presence of background or environmental noise, although daily activities may still be performed. Less noticeable when concentrating. Not infrequently interferes with sleep and quiet activities.

1030. In my judgment Mr Craggs' tinnitus should be regarded as at the upper end of the mild category or the lower end of the moderate category. The JC Guidelines do not provide exactly for such injury but in my view the appropriate award of damages is one of £19,000. Interest on general damages will be 2% pa in the usual way.

(iv) Hearing Aids and Tinnitus Treatment

1031. In the light of my conclusions about tinnitus, I accept that he should also have the benefit of tinnitus counselling. I accept Dr Nassar's opinion that a maximum of three sessions should suffice to provide basic education and coping strategies. I allow the sum of £445.

1032. I reject the claim in respect of a tinnitus relaxer or pillow. In that regard I accept Dr Nassar's evidence that

> A tinnitus relaxer was not reasonable. Mr Craggs would be better served by using his mobile phone, with an app with a wide library of masking sounds.

1033. I make no award for hearing aids. My decision that his hearing loss does not flow from NIHL in the military means that he is not entitled to hearing aids for that loss. As to the possibility of hearing aids to manage tinnitus, I accept Dr Nassar's evidence. He said:

> "*Mr Craggs does not need hearing aids now. He may have required hearing aids in an attempt to reduce his tinnitus awareness however tinnitus management and information/counselling sessions would be more beneficial. His tinnitus awareness is mainly in quiet at night, he can distract himself away from his tinnitus during the day and he would not be able to wear his hearing aids in his current role*".

1034. I also note in this context that Mr Hussnain accepted that if I were to conclude that the Claimant's account of his hearing difficulties was unreliable, then, given the mildness of the hearing loss, there would be little basis on which to recommend hearing aids.

1035. In any event, I do not accept that, on the balance of probabilities, Mr Craggs is likely to purchase hearing aids privately and on the authority of Woodrup v. Nicol [1993] PIQR Q104 (CA) a Claimant cannot recover for the cost of private medical equipment that he is unlikely to obtain. I reach that conclusion in the light of the fact that despite having tinnitus (and he says hearing loss) for 20 years or more he has never sought hearing aids either privately or on the NHS, and the benefit he would gain from them in respect of tinnitus would be minimal.

Conclusions

1036. It follows that I value Mr Craggs' claim as follows:

- General Damages for PSLA £19,000
- Interest on general damages at 2% pa
- Tinnitus counselling £445

1037. I make no award for hearing aids. The total figure falls to be reduced by 25% to reflect the application of the Matrix.

1038. I will hear counsel on the appropriate form of the Order I should make.