Appeal by: Bristol Airport Limited

Appeal Reference: APP/D0121/W/20/3259234

North Somerset Council Application Reference: 18/P/5118/OUT

Proof of evidence of

Dani Fiumicelli BSc (Hons), MSc, MCIEH, MIOA

Noise

Reference: NSC/W2/1

Vanguardia

BRISTOL AIRPORT PLANNING APPEAL

PLANNING INSPECTORATE REFERENCE: APP/D0121/W/20/3259234

VC-103362-AA-RP-0001

R00

15TH JUNE 2021

PROOF OF EVIDENCE ON NOISE

DANI FIUMICELLI

FOR THE NORTH SOMERSET COUNCIL

NORTH SOMERSET COUNCIL REFERENCE: 18/P/5118/OUT

PROOF OF EVIDENCE ON NOISE AN APPEAL BY BRISTOL AIRPORT LIMITED PURSUANT TO SECTION 78 OF THE TOWN AND COUNTRY PLANNING ACT 1990 AGAINST THE DECISION OF NORTH SOMERSET COUNCIL TO REFUSE TO GRANT OUTLINE PLANNING PERMISSION, WITH SOME RESERVED MATTERS INCLUDED AND OTHERS RESERVED FOR SUBSEQUENT APPROVAL, FOR THE DEVELOPMENT OF BRISTOL AIRPORT, NORTH SIDE ROAD, FELTON, WRINGTON, BS48 3DP PINS REF: APP/X5210/Y/20/3248003 & APP/X5210/W/20/3248002

VANGUARDIA

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1. INTRODUCTION, SCOPE OF EVIDENCE & REASONS FOR REFUSAL

INTRODUCTION

1.1. This proof of evidence is submitted to the inquiry on behalf of the North Somerset Council (NSC) regarding an appeal by Bristol Airport Limited (BAL) pursuant to section 78 of the Town and Country Planning Act 1990 against the decision of NSC to refuse to grant outline planning permission, with some reserved matters included and others reserved for subsequent approval, for the development of Bristol Airport, North Side Road, Felton, Wrington, BS48 3DP PINS ref: APP/X5210/Y/20/3248003 & APP/X5210/W/20/3248002.

1.2. The refused application sought outline planning permission (with some reserved matters included) to increase the operational capacity of Bristol Airport from its current cap of 10 MPPA up to 12 MPPA. Currently at night the existing planning permission permits a maximum of 3000 flights in the British Summer Time and 1000 movements in the British Winter Time. BAL propose to retain the annual cap of 4000 night-time flights at 12 MPPA, but remove the seasonal restrictions. The application included various additions to the terminal, an additional multi-storey car park (MSCP3), a two-lane gyratory road system; alterations to the taxi ways and aircraft stands, removal of the seasonal restriction on the use of the 'Cogloop' 3,650 space car-park, an extension to the 'Silver Zone' car park comprising approximately 2,700 additional spaces. Off- site works include alterations to the A38 highway at the Downside Road and West Lane junctions as well as carriageway improvements to a section of the existing A38.

SCOPE OF EVIDENCE

1.3. This evidence covers the potential noise effects of the proposals and their potential effects upon the health and well-being of residents in local communities.

1.4. This evidence refers to national and local planning policies and guidance but leaves detailed discussion of those policies and their implications to the NSC planning witness, Mr. Gurtler.

1.5. Similarly, my evidence relies on data on the number of air traffic movements (ATMs) to and from the airport and the types of aircraft making up the fleet using the airport, as these are fundamental elements of how airport noise can be modelled and predicted. However, I leave detailed discussion of ATMs and the potential fleet mix of aircraft using the airport to Mr Folley, the NSC witness on forecasting.

REASONS FOR REFUSAL

1.6. The noise related reasons for refusing planning permission are reproduced below:

"1. The airport has planning permission to expand to a throughput of 10 million passengers per annum (mppa) which allows for further expansion in passenger growth of approximately 1 mppa above the current passenger level. The further expansion beyond 10mppa now proposed would generate additional noise, traffic and off airport car parking resulting in adverse environmental impacts on communities surrounding Bristol Airport and which would have an adverse impact on an inadequate surface access infrastructure. The claimed economic benefits arising from the proposal would not outweigh the environmental harm caused by the development contrary to policy CS23 of the North Somerset Core Strategy 2017.

2. The noise and impact on air quality generated by the increase in aircraft movements and in particular the proposed lifting of seasonal restrictions on night flights would have a significant adverse impact on the health and well-being of residents in local communities and the Proposed Development would not contribute to improving the health and well-being of the local population contrary to policies CS3, CS23 and CS26 of the North Somerset Core Strategy 2017."

2. QUALIFICATIONS & PERSONAL STATEMENT

2.1. **Qualifications and Experience**

2.2. I am a technical director of Vanguardia Limited, a company whose services include specialising in the field of acoustics, noise, and vibration. I was awarded the Chartered Institute of Environmental Health's Diploma in 1986 and a Master of Science (MSc) in Environmental Acoustics from the Southbank University in 1999; and have over 30 years of experience in the field of acoustics having worked as an Environmental Health Officer in London from 1986 until 2002, and as an acoustic consultant in the private sector since then. I am a corporate member of the Institute of Acoustics (IoA) and the Chartered Institute of Environmental Health Officers (CIEH), and I am a member of the IoA Environmental Noise Committee. I was chair of a committee set up by the IOA, the Association of Noise Consultants and the CIEH which published good practice guidance regarding noise sensitive development in May 2017 and am a member of a working groups revising the IOA Good Practice Guide to Noise from Place of Entertainment and from outdoor concerts. I have a wide range of experience in all technical aspects related to acoustics and have managed numerous projects as well as presenting evidence at planning committees and appeals, legal proceedings, public inquiries and House of Commons and Scottish Parliament Scrutiny Committees. I have presented technical papers and written articles nationally and internationally on noise and acoustics covering a wide range of aspects. My overall project experience includes being the project director or manager and participant in Environmental Impact Assessments for residential schemes, schools, airports, road transport, guided transport (trams and buses), light and heavy railway projects, renewable energy, hospital development, mixed developments, harbour developments, leisure developments, sport stadiums, and commercial and industrial developments. My airport specific experience includes being an expert noise witness at public inquiries for the Heathrow, London City, Farnborough and Ronaldsway, Isle of Man Airports; advising the Heathrow Community

Engagement Board, supporting Slough Borough Council on the Heathrow Airport Expansion – 3rd Runway and Independent Parallel Approaches plans; developing a methodology for assessing the Impacts of Aviation Noise on Heritage Assets for English Heritage; and being the discipline lead and project manager for the noise and vibration chapter of the ES for a second parallel main runway at Calgary International Airport.

2.3. I have visited the vicinity of the proposed scheme and viewed the existing airport layout and the relationship with the nearest noise sensitive properties affected by ground and air noise from publicly accessible areas around the scheme. I have also visited communities and settlements further away that are affected by the noise from aircraft travelling to and from the airport.

2.4. **Personal Statement**

I, Dani Fiumicelli declare that:

2.4.1. The evidence which I have prepared and provide for this appeal reference APP/D0121/W/20/3259234, in this proof of evidence is true and has been prepared and is given in accordance with the guidance of my professional institutions, and I confirm that the opinions expressed are my true and professional opinions.

2.4.2. I understand that my duty in providing this statement and giving evidence is to help the Inquiry, and that this duty overrides any obligation to the party by whom I am engaged or the person who has paid or is liable to pay me or my employers. I confirm that I have complied and will continue to comply with my duty.

2.4.3. I confirm that insofar as the facts stated in this statement are within my own knowledge I have made clear which they are, and I believe them to be true, and that the opinions I have expressed represent my true and complete professional opinion.

2.4.4. I have endeavoured to include in my statement those matters, of which I have knowledge or which I have been made aware, that might adversely affect the validity of my opinion. I have clearly stated any qualifications to my opinion.

2.4.5. I have shown the sources of all information I have used.

2.4.6. I have not without forming an independent view included or excluded anything which has been suggested to me by others; including my instructing clients and their lawyers.

2.4.7. I will notify those instructing me immediately and confirm in writing if for any reason my statement requires any correction or qualification.

3. POLICY AND GUIDANCE

NATIONAL POLICY AND GUIDANCE

Aviation Policy Framework (APF) (CD6.1)

3.1. The APF sets out the framework for noise management at UK airports.

3.2. The APF identifies that the Government's overall objective on noise "*is to limit and where possible reduce the number of people in the UK significantly affected by aircraft noise*" (Executive Summary para. 17; main text para. 3.12); and that Government fully recognises the International Civil Aviation Authority (ICAO) Assembly '*balanced approach*' principle to aircraft noise management[1] (para 3.7).

3.3. Within the Section on noise and other local environmental impacts, the APF states at para 3.3: "*We want to strike a fair balance between the negative impacts of noise (on health, amenity (quality of life) and productivity) and the positive economic impacts of flights*".

3.4. The APF makes clear that the acceptability of growth in aviation depends to a large extent on the industry continuing to tackle its noise impact and confirms that the Government expects the industry at all levels to continue to address noise (Executive Summary, para 17). Within the Section on Noise and other local environmental impacts, para 3.3 goes on to state:

"As a general principle, the Government therefore expects that future growth in aviation should ensure that benefits are shared between the aviation industry and local communities. This means that the industry must continue to reduce and mitigate noise as airport capacity grows.

[1] Given further effect through para 2.97 and 2.137 of the Consultation Response on UK Airspace Policy, DfT, October 2017

As noise levels fall with technology improvements the aviation industry should be expected to share the benefits from these improvements.'

3.5. This means that the industry must continue to reduce and mitigate noise as airport capacity grows. As noise levels fall with technology improvements the aviation industry is expected to share the benefits from these improvements.

3.6. The Government expectation is that growth in airport capacity is not to be delivered via increased aviation noise impacts; rather growth is to be managed so that noise impacts are mitigated and reduced. Growth which is delivered via increased noise impacts is not therefore growth that accords with the policy objectives of the APF.

3.7. This policy approach directly aligns within the principles of sustainable development as is required when applying the Government's overarching noise policy, the NPSE.

3.8. The APF discusses the metrics used to assess airport noise and at paragraph 3.19 states – "*Average noise exposure contours are a well-established measure of annoyance and are important to show historic trends in total noise around airports. However, the Government recognises that people do not experience noise in an averaged manner and that the value of the LAeq indicator does not necessarily reflect all aspects of the perception of aircraft noise. For this reason, we recommend that average noise contours should not be the only measure used when airports seek to explain how locations under flight paths are affected by aircraft noise. Instead, the Government encourages airport operators to use alternative measures which better reflect how aircraft noise is experienced in different localities,*[96] *developing these measures in consultation with their consultative committee and local communities. The objective should be to ensure a better understanding of noise impacts and to inform the development of targeted noise mitigation measures*."

3.9. Footnote 96 referred to in the above extract – "*Examples include frequency and pattern of movements and highest noise levels which can be expected*."

3.10. The APF clearly expects those promoting change in how airport noise is generated and distributed not to rely solely on the energy averaging metrics such as the LAeq, 16 hr during the day and LAeq 8 hr at night; rather a more targeted approach is required which will reflect how noise is experienced in the particular locality in question.

Noise Policy Statement for England (NPSE) (CD10.4)

3.11. NPSE seeks to clarify the underlying principles and aims in existing policy documents, legislation and guidance that relate to noise. The statement applies to all forms of noise, including environmental noise, neighbour noise and neighbourhood noise.

3.12. The statement sets out the long-term vision of the Government's noise policy, which is to "*promote good health and a good quality of life through the effective management of noise within the context of policy on sustainable development*".

3.13. The NPSE provides definitions of health and quality of life as follows:

"2.12 The World Health Organisation defines health as a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity, and recognises the enjoyment of the highest attainable standard of health as one of the fundamental rights of every human being.

2.13 It can be argued that quality of life contributes to our standard of health. However, in the NPSE it has been decided to make a distinction between "quality of life" which is a subjective measure that refers to people's emotional, social and physical well being and "health" which refers to physical and mental well being.

2.14 It is recognised that noise exposure can cause annoyance and sleep disturbance both of which impact on quality of life. It is also agreed by many experts that annoyance and sleep disturbance can give rise to adverse health effects. The distinction that has been made between "quality of life" effects and "health" effects recognises that there is emerging evidence that *long term exposure to some types of transport noise can additionally cause an increased risk of direct health effects. The Government intends to keep research on the health effects of long term exposure to noise under review in accordance with the principles of the NPSE."*

3.14. The policy promotes the effective management and control of noise, within the context of Government policy on sustainable development and thereby aims to:

- avoid significant adverse impacts on health and quality of life;
- mitigate and minimise adverse impacts on health and quality of life; and
- where possible, contribute to the improvements of health and quality of life.

3.15. The statement adopts established concepts from toxicology that are currently being applied to noise impacts. The concept details noise levels, at which the effects of an exposure may be classified into a specific category. The classification categories as detailed within the NPSE are as follows:

- No Observed Effect Level (NOEL) - the level below which no effect can be detected. Below this level no detectable effect on health and quality of life due to noise can be established;
- Lowest Observable Adverse Effect Level (LOAEL) - the level above which adverse effects on health and quality of life can be detected; and
- Significant Observed Adverse Effect Level (SOAEL) - the level above which significant adverse effects on health and quality of life occur.

3.16. It is recognised that SOAEL does not have a single objective noise-based level that is applicable to all sources of noise in all situations and therefore the SOAEL is likely to be different for different sources, receptors and at different times of the day.

3.17. No guidance has been issued at the time of writing to identify the noise levels that represent SOAEL and LOAEL for typical noise sources and receptors.

Draft UK Airspace Policy, DfT, February 2017 and Consultation Response, DfT, October 2017 (CDs 10.32 & 10.33)

3.18. The Draft UK Airspace Policy and Consultation Response is important as it effectively amends certain noise-related aspects of the Aviation Policy Framework (APF), for example:

- '*The Government's current aviation policy is set out in the Aviation Policy Framework (APF). The policies set out within this document provide an update to some of the policies on aviation noise contained within the APF and should be viewed as the current government policy*.' (para 9)
- '*Consistent with the Noise Policy Statement for England, our objectives in implementing this policy are to: … limit and, where possible, reduce the number of people in the UK significantly affected by the adverse impacts from aircraft noise*.' (para 2.69)
- '*We will set a LOAEL at 51dB LAeq,16h for daytime and based on feedback and further discussion with CAA we are making one minor change to the LOAEL night metric to be 45dB LAeq,8h rather than Lnight to be consistent with the daytime metric.'* (para 2.72).

3.19. In Addition, the consultation response identifies that (para 2.70): "*The government acknowledges the evidence from recent research which shows that sensitivity to aircraft noise has increased, with the same percentage of people reporting to be highly annoyed at a level of 54 dB LAeq 16hr as occurred at 57 dB LAeq 16 hr in the past. The research also showed that some adverse effects of annoyance can be seen to occur down to 51dB LA*eq". This serves to confirm a change in the Government's view as stated in the APF (3.17)"*to treat the 57dB LAeq 16 hour contour as the average level of daytime aircraft noise marking the approximate onset of significant community annoyance*". This is a significant change in policy as it confirms that reliance upon the 57 dB LAeq, 16hr metric as used to limit and restrict noise at many UK airports no longer has a policy basis.

3.20. This is relevant to BAL's proposals regarding their assessment of significant noise effects and proposed noise contour restriction because the Government's policy objective is to "*limit and reduce*" and as such limits on noise exposure should be set having regard for relevant policy, evidence-base and the associated effects.

National Planning Policy Framework (NPPF) (CD 5.8)

3.21. Paragraph 170 of the NPPF advises that:

"170 (e) Planning policies and decisions should contribute to and enhance the natural and local environment by:

"preventing new and existing development from contributing to, being put at unacceptable risk from, or being adversely affected by, unacceptable levels of soil, air, water or noise pollution or land instability.

3.22. Paragraph 180 of the NPPF comments further on noise as follows:

"*Planning policies and decisions should also ensure that new development is appropriate for its location taking into account the likely effects (including cumulative effects) of pollution on health, living conditions and the natural environment, as well as the potential sensitivity of the site or the wider area to impacts that could arise from the development. In doing so they should:*

- *mitigate and reduce to a minimum, potential adverse impacts resulting from noise from new development – and avoid noise giving rise to significant adverse impacts on health and the quality of life*[60];

- *identify and protect tranquil areas which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason;"*

Foot Note 60 - See Explanatory Note to the Noise Policy Statement for England (Department for Environment, Food & Rural Affairs, 2010).

Air Navigation Guidance 2017 (CD10.12)

3.23. The UK Air Navigation Guidance contains the Secretary of State's (SofS) guidance to the CAA on its environmental objectives when carrying out its air navigation functions, with the intention to guide both the CAA and aviation industry on how their decisions can best give effect to the governments Key Environmental Objectives, which are as follows:

'a. limit and, where possible, reduce the number of people in the UK significantly affected by adverse impacts from aircraft noise;

b. ensure that the aviation sector makes a significant and cost-effective contribution towards reducing global emissions; and

c. minimise local air quality emissions and in particular ensure that the UK complies with its international obligations on air quality.'

3.24. The ANG17 also seeks to clarify the Government's position in relation to aviation noise policy. It confirms the setting of daytime and night-time policy LOAELs for aviation noise in the context of the Government's environmental objectives, which through the setting of LOAELs is consistent with the NPSE, as is stated by the APF.

3.25. Although in the context of airspace change, the ANG17 provides guidance as to how its overarching policy objective should be interpreted. It states (para 3.5):

"*interpret this objective to mean that the total adverse effects on people as a result of aviation noise should be limited and, where possible, reduced, rather than the absolute number of* *people in any particular noise contour. Adverse effects are considered to be those related to health and quality of life*."

3.26. In this context, the Government intends that their objective be considered not solely by reference to a single contour, or threshold, but by reference to the adverse effects relating from aircraft noise as a consequence of the numbers of people exposed to it, irrespective of level. To support this the Department for Transport prepared its WebTAG model for evaluating the impact of and change to aircraft noise. Whilst this module is not a comprehensive assessment tool, it allows the calculations of health endpoints by virtue of the number of people exposed at different levels of aircraft noise exposure, applying 'dose response relationships' to yield the number of people affected and the associated health outcomes. In Section 4 of my evidence below, I explain the evidence which underpins these 'dose response relationships'.

3.27. The ANG17 also requires that other noise assessment metrics should be provided and considered in addition to the outcomes from the WebTAG assessments (Chapter 3).

3.28. The guidance provided by DfT within ANG17 has been developed into a process by the Civil Aviation Authority (CAA) which is reported within CAP1616. This publication is supported by an environmental requirements technical annex, CAP1616a. This publication is relied on by practitioners working on both airport development and airspace change projects to development methodologies and to assist in communicating aircraft noise effects.

Aviation 2050 – The Future of UK Aviation, A Consultation (CD 6.5)

3.29. Aviation 2050 was published as a consultation in 2018 and provides Government thinking on its strategy for aviation to 2050, and it indicates how the Government wishes to consider aviation growth alongside environmental effects.

3.30. The consultation indicates the Government's support for growth in the aviation but states that growth (page 7) "*must be coupled with steps to mitigate environmental damage such as carbon emission, noise and air quality*".

3.31. Aviation 2050 recognises the following within paragraph 1.26:

- There is evidence that the public are becoming more sensitive to noise
- That there are health costs associated with aircraft noise
- Efforts to reduce and manage noise impacts must continue

3.32. Paragraph 3.106 of Aviation 2050 states that:

"*There is also evidence that the public is becoming more sensitive to aircraft noise, to a greater extent than noise from other transport sources, and that there are health costs associated from exposure to this noise. The government is considering the recent new environmental noise guidelines for the European region published by the World Health Organisation (WHO). It agrees with the ambition to reduce noise and to minimise adverse health effects, but it wants policy to be underpinned by the most robust evidence on these effects, including the total cost of action and recent UK specific evidence which the WHO report did not assess.*"

3.33. Aviation 2050 introduces initiatives that the Government is considering as part of the noise management frameworks applying to UK airports, and how it sees its policy objective being interpreted. This includes progressively reducing the noise from individual flights and setting the expectation that airports should share the benefits of growth through community funds. The consultation states that "*The government expects the industry to show continuing commitment to noise reduction and mitigation as part of its contribution to the partnership for sustainable growth.*"

3.34. The consultation also refers to a policy direction "*towards a stronger noise policy framework*". Within this, the Government identifies several potential new measures "*which address weaknesses within in current policy*" (APF) and "*ensure industry is sufficiently incentivised to reduce noise, or to put mitigation in place where reductions are not possible*". These are reproduced in turn (para 3.115):

"setting a new objective to limit, and where possible, reduce total adverse effects on health and quality of life from aviation noise". (para 3.115, bullet 1)

3.35. The stated aim of this measure is to "*bring national noise aviation policy in line with airspace policy updated in 2017*". Such a change would in effect require airport developers to present the impacts of their proposals in the context of health-based metrics and would set the objective that these should be limited, and where possible reduced. It should be noted that under airspace policy i.e. Air Navigation Guidance 2017, the primary assessment metric for aircraft noise as outlined above is monetised health impacts, as articulated by the Government's WebTAG methodology. Under airspace policy, aircraft noise assessment complements the NPSE through the setting of LOAELs and allowing noise effects to be presented in terms of health outcomes through the WebTAG assessment framework e.g.

"*developing a new national indicator to track the long-term performance of the sector in reducing noise" (para 3.115, bullet 2*)

3.36. With respect to this proposed measure, work towards this was explored and investigated by the CAA in CAP1731 'Aviation strategy: Noise Forecast and Analyses'. This report is a supporting document for the Aviation 2050 consultation and it describes a range of metrics which could be used to track how noise impacts from individual airports contribute towards the Government's overall objective to "*limit and, where possible, reduce the number of people in the UK significantly affected by aircraft noise*".

3.37. CAP1731 recommends that a proposed limit scheme would contain the following:

- *"National LAeq or Lden limit on the area exposed to at least 51 or 54 dB;*
- *National night-time limit on the area exposed (LAeq8h or Lnight) to at least 45 or 48 dB;*
- *National LAeq or Lden limit on the area exposed to at least 51 or 54 dB normalised by transport volume (ATMs);*
- *National night-time limit on the area exposed (LAeq8h or Lnight) to at least 45 or 48 dB normalised by traffic volume (ATMs);*
- *National NAx[2] limit on the area exposed to at least 5 or 10 events per average summer day above 65 or 70 dB LAmax or 60 dB LAmax per average summer night;*
- *National limit based on average summer daytime total number of person-events above 70dB LAmax, PEI(70) 10 events;*
- *National limit based on summer daytime Average individual exposure of events above 70 dB LAmax, AIE(70) 10 events;*
- *Local daytime (LAeq or Lden), (54 or 51) dB contour area limit;*
- *Local night time (LAeq8h or Lnight), (48 or 45) dB contour area limit;*
- *Local NAx limit on the area exposed to at least 5 or 10 events per average summer day above 65 or 70 dB LAmax or 60 dB LAmax per average summer night*."

3.38. What is clear from this narrative is that any national objective being considered by Government needs to be reciprocated locally by the major airports. With respect to noise contour area limits, which have relevance in this case since this forms part of the Appellant's proposals, the following metrics are considered by the CAA. In addition to noise contour area limits, CAP1731

[2] NAx is short form for the area in Km^2 within which the number of aircraft noise events would exceed an LAmax value of 65 dB or 70 dB during the day or 60 dB at night at least 5 or 10 times.

also introduces the concept of limiting 'heath impacts'. The CAA report indicates that 'local monitoring' of the number of people highly annoyed and highly sleep disturbed could also form part of a national limit scheme by.

"routinely setting noise caps as part of planning approvals (for increase in passengers or flights)" (para 3.115, bullet 3)

3.39. Aviation 2050 states that the aim of this measure is to "*balance noise and growth and to provide future certainty over noise levels to communities*". It states that *"It is important that caps are subject to periodic review to ensure they remain relevant and continue to strike a fair balance by taking account of actual growth and the introduction of new aircraft technology. It is equally important that there are appropriate compliance mechanisms in case such caps are breached and the government wants to explore mechanisms by which airports could 'pay for' additional growth by means of local compensation as an alternative to the current sanctions available*". (3.115, bullet 3)

3.40. This statement recognises that noise-related operating restrictions need to be set in a manner whereby they provide certainty of impact to both the airport operator and communities, and in a way that that the noise cap remains appropriate and relevant through routine review. By recognising the need for compliance mechanisms this also brings forward the requirement for routine and reliable reporting of the metrics which comprise the noise cap.

3.41. This is entirely consistent with the policy of setting 'noise envelopes' as described within the APF (para 3.29) which states that:

"*The Government wishes to pursue the concept of noise envelopes as a means of giving certainty to local communities about the levels of noise which can be expected in the future and to give developers certainty on how they can use their airports*".

National Planning Practice Guidance (NPPG) (CD 5.9)

3.42. The Planning Practice Guidance (PPG) is issued by the Department of Communities and Local Government and in the Noise Exposure Hierarchy at Paragraph: 005 Reference ID: 30-005-20190722 Revision date: 22 07 2019, expands on the use of Lowest Observed Adverse Effect Level (LOAEL) and Significant Observed Adverse Effect Level (SOAEL) as follows:

LOAEL - "*Noise can be heard and causes small changes in behaviour, attitude or other physiological response, e.g. turning up volume of television; speaking more loudly; where there is no alternative ventilation, having to close windows for some of the time because of the noise. Potential for some reported sleep disturbance. Affects the acoustic character of the area such that there is a small actual or perceived change in the quality of life.*".

3.43. Thus, the PPG is explicit in saying that although noise can be heard, the effects have been mitigated and minimised as far as is practicable and this is the lower limit that policy requires i.e. there is no policy imperative to achieve Noise Observed Effect Level (NOEL) i.e. for noise to be inaudible.

3.44. The Noise Exposure Hierarchy in the PPG goes on to describe the effects of SOAEL as follows:

"The noise causes a material change in behaviour, attitude or other physiological response, e.g. avoiding certain activities during periods of intrusion; where there is no alternative ventilation, having to keep windows closed most of the time because of the noise. Potential for sleep disturbance resulting in difficulty in getting to sleep, premature awakening and difficulty in getting back to sleep. Quality of life diminished due to change in acoustic character of the area."

3.45. In the same section the PPG also goes on to identify unacceptable noise exposure as:

"*Extensive and regular changes in behaviour, attitude or other physiological response and/or an inability to mitigate effect of noise leading to psychological stress, e.g. regular sleep* *deprivation/awakening; loss of appetite, significant, medically definable harm, e.g. auditory and non-auditory*."

3.46. At Paragraph: 002 Reference ID: 30-002-20190722 Revision date: 22 07 2019 the NPPG states that noise can override other planning considerations; with the qualification that: "*where justified, although it is important to look at noise in the context of the wider characteristics of a development proposal, its likely users and its surroundings, as these can have an important effect on whether noise is likely to pose a concern.* "

3.47. The NPPG at Paragraph: 003 Reference ID: 30-003-20190722 Revision date: 22 07 2019 advises that when dealing with noise aspects of planning applications Local Planning Authorities should "consider:

- whether or not a significant adverse effect is occurring or likely to occur;
- whether or not an adverse effect is occurring or likely to occur; and
- whether or not a good standard of amenity can be achieved".

3.48. Like the NPPF and NPSE, the NPPG does not contain any noise level decibel based standards or guidelines.

3.49. At Paragraph: 006 Reference ID: 30-006-20190722 Revision date: 22 07 2019, the NPPG recognises that "*The subjective nature of noise means that there is not a simple relationship between noise levels and the impact on those affected. This will depend on how various factors combine in any particular situation*." And that,

"*These factors include*:

- *The source and absolute level of the noise together with the time of day it occurs. Some types and level of noise will cause a greater adverse effect at night than if they occurred during the day – this is because* *people tend to be more sensitive to noise at night as they are trying to sleep. The adverse effect can also be greater simply because there is less background noise at night;*

- *for a new noise making source, how the noise from it relates to the existing sound environment;*
- *for non-continuous sources of noise, the number of noise events, and the frequency and pattern of occurrence of the noise;*
- *the spectral content of the noise (i.e. whether or not the noise contains particular high or low frequency content) and the general character of the noise (i.e. whether or not the noise contains particular tonal characteristics or other particular features), and;*
- *the local arrangement of buildings, surfaces and green infrastructure, and the extent to which it reflects or absorbs noise.*

More specific factors to consider when relevant include:

- *the cumulative impacts of more than one source of noise;*
- *whether any adverse internal effects can be completely removed by closing windows and, in the case of new residential development, if the proposed mitigation relies on windows being kept closed most of the time (and the effect this may have on living conditions). In both cases a suitable alternative means of ventilation is likely to be necessary. Further information on ventilation can be found in the Building Regulations.*
- *In cases where existing noise sensitive locations already experience high noise levels, a development that is expected to cause even a small increase in the overall noise level may result in a significant adverse effect occurring even though little to no change in behaviour would be likely to occur.*
- *Noise Action Plans (where these exist), and, in particular the Important Areas identified through the process associated with the Environmental Noise Directive and corresponding regulations should be taken into account. Defra's website has information on Noise Action Plans and Important Areas. Local authority environmental health departments will also be able to provide information about Important Areas.*

- *the effect of noise on wildlife. Noise can adversely affect wildlife and ecosystems. Particular consideration needs to be given to the potential effects of noisy development on international, national and locally designated sites of importance for biodiversity;*

- *where external amenity spaces are an intrinsic part of the overall design, the acoustic environment of those spaces should be considered so that they can be enjoyed as intended.*

- *some commercial developments including restaurants, hot food takeaways, night clubs and public houses can have particular impacts, not least because activities are often at their peak in the evening and late at night. Local planning authorities will wish to bear in mind not only the noise that is generated within the premises but also the noise that may be made by customers in the vicinity.*

3.50. The NPPG also provides guidance on "*What factors are relevant if seeking to identify areas of tranquillity*?" as follows:

> *"For an area to justify being protected for its tranquillity, it is likely to be relatively undisturbed by noise from human sources that undermine the intrinsic character of the area. It may, for example, provide a sense of peace and quiet or a positive soundscape where natural sounds such as birdsong or flowing water are more prominent than background noise, e.g. from transport.*
>
> *Consideration may be given to how existing areas of tranquility could be further enhanced through specific improvements in soundscape, landscape design (e.g. through the provision of green infrastructure) and/or access*."

Paragraph: 008 Reference ID: 30-008-20190722 Revision date: 22 07 2019

NSC CORE STRATEGY (CD5.20)

3.51. The North Somerset Core Strategy includes polices CS3, CS23 and CS 26 which are relevant to the consideration of the noise impacts of the proposed development:

CS3: Environmental impacts and flood risk assessment

"Development that, on its own or cumulatively, would result in air, water or other environmental pollution or harm to amenity, health or safety will only be permitted if the potential adverse effects would be mitigated to an acceptable level by other control regimes, or by measures included in the proposals, by the imposition of planning conditions or through a planning obligation.

CS23: Bristol Airport

"Proposals for the development of Bristol Airport will be required to demonstrate the satisfactory resolution of environmental issues, including the impact of growth on surrounding communities and surface access infrastructure."

CS26: Supporting healthy living and the provision of health care facilities

"The planning process will support programmes and strategies which increase and improve health services throughout the district, promote healthier lifestyles and aim to reduce health inequalities. This will be achieved through:

1) Requiring Health Impact Assessments (HIA) on all large scale developments in the district that assess how the development will contribute to improving the health and well being of the local population;"

POLICY CONCLUSIONS

3.52. In summary National and local planning policy and guidance require that:

- The number of people in the UK significantly affected by aircraft noise is to be limited and where possible reduced.

- Future growth in aviation should ensure that benefits are shared between the aviation industry and local communities. This means that the industry must continue to reduce and mitigate noise as airport capacity grows. As noise levels fall with technology improvements the aviation industry should be expected to share the benefits from these improvements.
- Aviation growth is only acceptable where noise is reduced and residual effects mitigated.
- The worst, unacceptable, effects of noise on its own that remain despite mitigation, must be prevented; and,
- That the significant adverse effects of noise should be avoided; and,
- The adverse effects of adverse impacts should be mitigated and minimised;
- Harm to amenity and health by noise must be limited to acceptable levels;
- Quality of life shall be protected against adverse noise effects.
- Health should be improved where possible.

4. EFFECTS OF AVIATION NOISE

4.1. Noise can cause both auditory and non-auditory health effects. Noise-induced hearing loss is a major auditory health effect which although on the wane due to greater awareness and control remains highly prevalent in occupational settings noisy workplaces. Evidence of the non-auditory effects of environmental noise on public health is established and growing. Observational and experimental studies have shown that noise exposure leads to annoyance, disturbs sleep and causes daytime sleepiness, interferes with speech, disrupts certain activities, affects patient outcomes and staff performance in hospitals, increases the occurrence of hypertension and cardiovascular disease in exposed populations, and impairs teaching and learning in schools and educational establishments and the cognitive performance of schoolchildren.

4.2. As described above the auditory effects of noise include hearing loss from long term exposure to high levels of persistent noise e.g. noise in heavy industrial work places or short term exposure to very high levels of impulsive noise e.g. shooting/explosions. However, no community outside the perimeter of Bristol airport is exposed to noise levels high enough or for sufficient duration to present a significant risk of hearing damage so this matter is not considered any further in this evidence.

4.3. However, there are non-auditory effects of noise on health and quality of life that are relevant to this application; including annoyance and effects on sleep disruption and disturbance, cardiovascular function e.g. stroke, ischemic heart disease and hypertension, children's cognitive development, changes in breathing, disruption of communication e.g. speech interference; and activity interference e.g. teaching and learning. Some of which are discussed in the following sections of this evidence.

Annoyance

4.4. Noise can be annoying. The WHO Guidelines for Community Noise (2000) (CD10.1) provides a definition of annoyance as "*a feeling of displeasure associated with any agent or condition, known or believed by an individual or group to adversely affect them". However, apart from "annoyance*", people may feel a variety of negative emotions when exposed to community noise, and may report anger, disappointment, dissatisfaction, withdrawal, helplessness, depression, anxiety, distraction, agitation, or exhaustion [3 & 4]. Thus, although the term annoyance does not cover all the negative reactions, it is often used a convenient proxy for the wide range of subjective, conscious negative emotional impacts of noise characterised primarily by psychophysiological expressions, biological reactions, and mental states.

4.5. Annoyance is the most prevalent community response in a population exposed to environmental noise. Noise annoyance can result from noise interfering with daily activities, feelings, thoughts, sleep, or rest, and might be accompanied by negative emotional responses, such as anger, displeasure, exhaustion, and by stress-related symptoms. Annoyance affects well-being i.e. quality of life, and health, and because of the high number of people affected, annoyance substantially contributes to the burden of disease from environmental noise[5].

4.6. In noisy environments, people generally prefer to reduce the loudness of noise, avoid it, or leave the noisy area if possible. However, the study of noise annoyance is complicated by significant variability between individuals in their annoyance response to the same level of the same sound, and to different sounds e.g. the same sound could be unwanted noise and annoying to some people but acceptable to others. There is no definite relationship between the degree of annoyance or unpleasantness of noise and the risk of adverse health effects. For

[3] Job, R.F.S. (1993) The role of psychological factors in community reaction to noise. In Noise as a Public Health Problem, Vol. 3, pp. 47-79. Vallet, M. (ed.) INRETS: Arcueil Cedex, France.

[4] Fields,J.M.; de Jong,R.G.; Brown,A.L.; Flindell,I.H.; Gjestland,T.; Job,R.F.S.; Kurra,S.; Lercher,P.; SchuemerKohrs,A.; Vallet,M.; and Yano,T.: 1997. Guidelines for Reporting Core Information From Community Noise Reaction Surveys. J.Sound Vib., 5, vol. 206, pp. 685-695.

[5] Fritschi L, Brown AL, Kim R, Schwela DH, Kephalopoulos S, eds. Burden of disease from environmental noise. Bonn: World Health Organization, 2011

example, loud music may be pleasant and enjoyable to one group of people and annoying and disturbing to another group.

Sleep disturbance

4.7. Adequate and good quality sleep is a fundamental requirement for health and quality of life. For example, the review[6] into sleep effects of transportation noise underpinning the 2018 WHO Environmental Noise Guidelines for the European Region (CD 10.28) : states that "*Sleep is a biological imperative and a very active process that serves several vital functions [1]. Undisturbed sleep of sufficient length is essential for daytime alertness and performance, quality of life, and health [2]. Noise has been shown to fragment sleep, reduce sleep continuity, and reduce total sleep time [3,4]. Numerous experimental studies have demonstrated that sleep restriction causes, among others, changes in glucose metabolism and appetite regulation, an attenuated immune response to vaccination, impaired memory consolidation, and dysfunction of blood vessels [5–10]. These are precursors for manifest diseases like obesity, diabetes, high blood pressure, and probably also dementia [11,12]. The epidemiologic evidence that chronically disturbed or curtailed sleep is associated with the negative health outcomes mentioned above is overwhelming [1,13]. For these reasons, noise-induced sleep disturbance is considered one of the most important non-auditory effects of environmental noise exposure [14]*."

4.8. Whether noise will cause sleep disturbance depends not only on the overall noise energy over the sleep period, and the number of individual noise events and the related noise levels; but also on factors such as sleep stage, and individual noise susceptibility. Elderly people, children, shift-workers, and people with a pre-existing (sleep) disorder are thought of as vulnerable groups for noise induced sleep disturbance.

[6] Mathias Basner and Sarah McGuire, WHO Environmental Noise Guidelines for the European Region: A Systematic Review on Environmental Noise and Effects on Sleep, http://dx.doi.org/10.3390/ijerph15030519 (Last viewed 20th April 20121)

4.9. Repeated noise related disturbance disrupts sleep quality through changes in the stages of sleep structure, which include delayed sleep onset and early awakenings, reduced deep (slow-wave) and Rapid Eye Movement sleep, and an increase in time spent awake and in the superficial light sleep stages[7].

4.10. The short-term effects of noise-induced sleep disturbance include impaired mood, subjectively and objectively increased daytime sleepiness, and impaired cognitive performance[8]. In 2009, The WHO published the Night Noise Guidelines for Europe (NNGs) (CD10.33) which are an expert consensus linking health outcomes ranging from no substantial biological effects to increased risk of cardiovascular disease[9] (see panel 2 of the NNGs).

4.11. The WHO NNGs regard nocturnal external noise levels of less than Lnight[10] 55 dB to be an interim goal and Lnight 40 dB a long-term goal for the prevention of noise-induced health effects related to sleep disturbance.

4.12. The WHO Guidelines for Community Noise and the current edition of BS 8223 (CD 10.34) recognise that assessing the impacts of noise on sleep only in terms of overall energy averaging metrics over the whole night period, such as the LAeq, 8 hrs, can be insufficient to address all noise related sleep impacts. For example, research suggests that "*The equivalent noise level [i.e. LAeq,T] seems to be a suitable predictor for subjectively evaluated sleep quality but not for physiological disturbances of sleep*". Furthermore, many studies have shown clear exposure response relationships between the maximum level of individual noise events and impacts during sleep such as arousals i.e. changes in sleep stages less than fully conscious awakening,

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[7] See Basner M, Müller U, Elmenhorst EM. Single and combined effects of air, road, and rail traffic noise on sleep and recuperation. Sleep 2011; 34: 11–23; and Basner M, M üller U, Griefahn B. Practical guidance for risk assessment of traffic noise effects on sleep. Appl Acoust 2010; 71: 518–22.

[8] Basner M. Nocturn al aircraft noise increases objectively assessed daytime sleepiness. Somnologie 2008; 12: 110–17. And lmenhorst EM, El menhorst D, Wenzel J, et al. Effects of nocturnal aircraft noise on cognitive performance in the following morning: dose- Jarup L, Babisch W, Houthuijs D, et al, and the HYENA study team.
Hypertension and exposure to noise near airports: the HYENA study. Environ Health Perspect 2008; 116: 329–33. response relationships in laboratory and field. Int Arch Occup Environ Health 2010; 83: 743–51.

[9] Night noise guide lines for Europe. World Health Organisation (WHO), Copenhagen, Denmark, 2009 – panel 2..

[10] In the UK Lnight is the annual average LAeq,T noise level between for an 8 hour period between 23:00 and 07:00 hrs.

awakenings or body movements. Consequently, when assessing impacts of noise on sleep it is appropriate to supplement the assessment of the overall noise levels at night measured using the LAeq,T index by also considering the noise from individual noise events, typically described with either the LAmax,T or the SEL noise metrics.

4.13. Before going on to consider how to use LAmax,T or the SEL metrics to assess the impacts of discrete noise events on sleep it is worthwhile considering how noise can effect sleep.

4.14. Phrases like "sleep disturbance", "sleep interference" or 'sleep interruption' imply that the noise from individual noise events e.g. an aircraft movement, would fully awaken people who are asleep i.e. they would become completely fully conscious. However, the 'effects' of noise on sleep referred to in the WHO Guidelines and most of the research and wider literature etc. cover many impacts during sleep, not solely people being woken up. To understand the effects of these impacts it is important to recognise that sleep consists of a cycle of alternating stages which during a typical night repeats roughly every 90 minutes. This cycle consists of a "wake" phase, then stages 1 and 2 of light non-rapid eye movement (NREM) sleep, a stage 3 of heavy sleep followed by a stage of rapid eye movement (REM) heavy sleep.

4.15. Each stage of sleep has different characteristics as described below[11]:

- **Wake (W)** - The wake stage or stage W, depends on whether the eyes are open or closed. During eye-open wakefulness, there are alpha and beta electrical waves present in the brain, predominantly beta. As individuals become drowsy, and the eyes close, the alpha rhythm is the predominant pattern. An epoch[12] is considered stage W if it contains greater than 50% alpha waves and eye movements associated with wakefulness. [5]

[11] Patel AK, Reddy V, Araujo JF. Physiology, Sleep Stages. [Updated 2020 Apr 29]. In: Stat Pearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2021 Jan-. https://www.ncbi.nlm.nih.gov/books/NBK526132/ (last viewed 19th April 2021)

[12] Sleep studies typically use epochs that are a short interval of usually 20-60 seconds chosen to provide sufficient resolution to allow the variation in the factors chosen to describe sleep to be measured and assessed reasonably precisely. The sleep stage or state of each consecutive epoch within a bedrest episode is determined from the polygraphic sleep recording.

- **N1 (Stage 1)** - This is the lightest stage of sleep and starts when more than 50% of the alpha waves are replaced with low-amplitude mixed-frequency (LAMF) activity. There is muscle tone present in the skeletal muscle and breathing tends to occur at a regular rate. This stage tends to last 1 to 5 minutes, consisting of around 5% of the total cycle.

- **N2 (Stage 2)** - This stage represents deeper sleep as your heart rate and body temperature drop. It is characterized by the presence in the brain waves of sleep spindles, K-complexes, or both. These sleep spindles will activate the superior temporal gyri, anterior cingulate, insular cortices, and the thalamus. The K-complexes show a transition into a deeper sleep. They are single, long delta waves only lasting for a second. As deeper sleep ensues and the individual moves into N3. All of their waves will be replaced with delta waves. Stage 2 sleep lasts around 25 minutes in the initial cycle and lengthens with each successive cycle, eventually consisting of about 50% of total sleep.

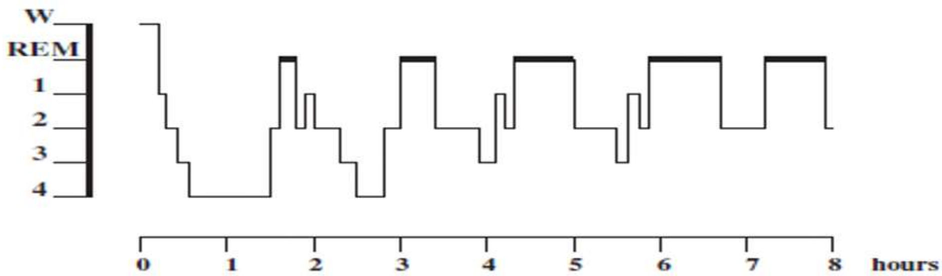
- **N3 (Stage 3)** - This is considered the deepest stage of sleep and is characterised by a much slower frequency electrical brain activity when high amplitude signals known as delta waves can be measured. This stage is the most difficult to awaken from, and for some people, even loud noises (over 100 decibels) will not awaken them. As people get older, they tend to spend less time in this slow, delta wave sleep and more time stage N2 sleep. This is the stage when the body repairs and regrows its tissues, builds bone and muscle, and strengthens the immune system. Although this stage has the greatest arousal noise level threshold, if someone is awoken during this stage, they will have a transient phase of mental fogginess. This is known as sleep inertia.

- **REM Sleep** - This is the stage associated with dreaming. Interestingly, the EEG is similar to an awake individual, but the skeletal muscles are atonic and without movement. The exception is the eye and diaphragmatic breathing muscles, which remain active. The breathing rate is altered though, being more erratic and irregular. This stage usually starts 90 minutes after you fall asleep, and each of your REM cycles gets longer throughout the night. The first period typically lasts 10 minutes, and the final one can last up to an hour.

4.16. The noise level threshold for awakening is highest in the stage 3 and REM stage of heavy sleep and is lower in the light sleep stages 1 and 2. The awakening noise threshold also depends on the characteristics of the noise e.g. intermittent noises or rapid on-set noise events have greater impact than continuous noise or slower onset noise events; as well as the connotation of the noise. Thus, for example, whispering the sleeper's name can awake the person more easily than a much louder but anonymous noise. Similarly, the noise of an alarm or warning will awaken a sleeper more easily than a noise of similar level without any particular meaning.

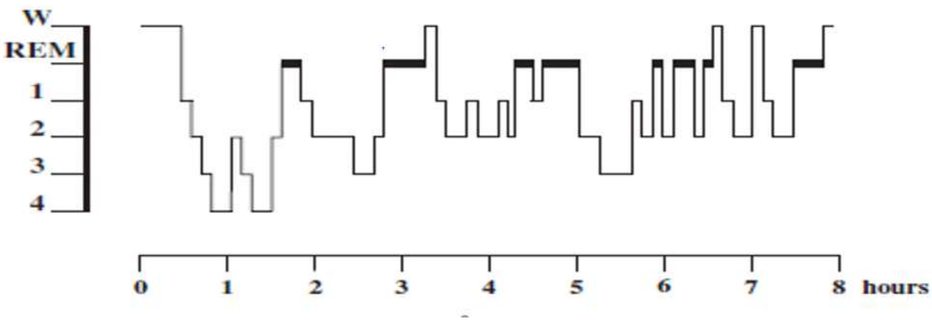
Noise affects sleep by increasing a person's arousal levels leading to a redistribution of time spent in the different stages of sleep. Stages 1 and 2 are more easily disturbed by noise so noise means more time is spent in these phases; with a concomitant reduction of time in the heavy sleep stage 3 and the REM parts of the cycle to compensate. The effects of noise events on the sleep cycle are demonstrated in the figures below[13].

FIGURE 1: AS UNDISTURBED SLEEP PROGRESSES LIGHT SLEEP STAGES 1 AND 2 GET SHORTER, AND DEEP SLEEP STAGES 3/4 AND REM SLEEP LENGTHEN



[13] From - Alain Muzet, Environmental noise, sleep and health, Sleep Medicine Reviews (2007) 11, 135–142

FIGURE 2: WITH NOISE DISTURBED SLEEP ONSET IS DELAYED, DEEP SLEEP STAGES 3/4 AND REM ARE FRAGMENTED AND AWAKENING OCCURS



4.17. Such sleep fragmentation has been shown to affect, among other effects, waking psychomotor function, next day performance, memory, creativity, risk – taking behaviour, mood, signal detection performance, daytime fatigue and tiredness and to increase accident risks. The degree to which these effects occur at any particular sound level varies between individuals making a person's response difficult to predict, but the likelihood of an effect happening in an exposed population can be established.

4.18. Classification and determination of sleep states is best achieved using a polysomnograph (a multi-channel electronic device which records brainwave, heart, muscle and breathing data). An important general finding of sleep research is that the noise levels at which impacts occur in laboratory-based studies are lower, often by a substantial degree, than those found in field studies. This is thought to be due to the unfamiliar nature of laboratory conditions compared to the circumstances in a test subject's own bedroom to which they have adapted/habituated too over time. Consequently, field sleep studies in the subject's home are regarded as more reliable means of testing the effects of noise on sleep that laboratory based experiments. Until relatively recently polysomnographs were large complex and cumbersome items of equipment best used in controlled laboratory conditions rather than in a bedroom at home. However, modern sleep studies benefit from the availability of smaller and more convenient polysomnographs better suited to use in field studies than previous generations of equipment.

Even so, there are currently only a small number of suitable polysomnography based field studies on the effects of noise on sleep. Consequently, other studies using different means of appraising noise effects on sleep may also need to be considered e.g. motility and self-recording and reporting.

4.19. It is important to recognise that typically many awakening events are unrelated to noise and that normally the average person is subject to several spontaneous awakenings per night independent of any effects of noise. For example, the WHO Community Noise Guidelines at section 3.4 advises that "*It is estimated that 80-90% of the reported cases of sleep disturbance in noisy environments are for reasons other than noise originating outdoors. For example, sanitary needs; indoor noises from other occupants; worries; illness; and climate (e.g. Reyner & Horne 1995)*".

4.20. It is also important to understand what the word 'awakening' means. When the word is used colloquially, most regard it as meaning being fully awake to the degree that they can recall having been awakened the following morning. Some noise and sleep research has focussed on this type of awakening by requiring the subject to press a button to record their awakening (this is called a 'behavioural awakening'). However, the scientific meaning of the term awakening covers a wider range of responses, many of which do not involve awareness or recollection of being conscious. To understand the results of the research of the effects of noise on sleep it is therefore important to be able to distinguish between various kinds of awakening, for example:

- Behavioural or recalled awakening - equivalent to the everyday understanding of conscious 'awakening', when the subject is usually aware of being conscious at the time and can often recall being "awake" the next day;

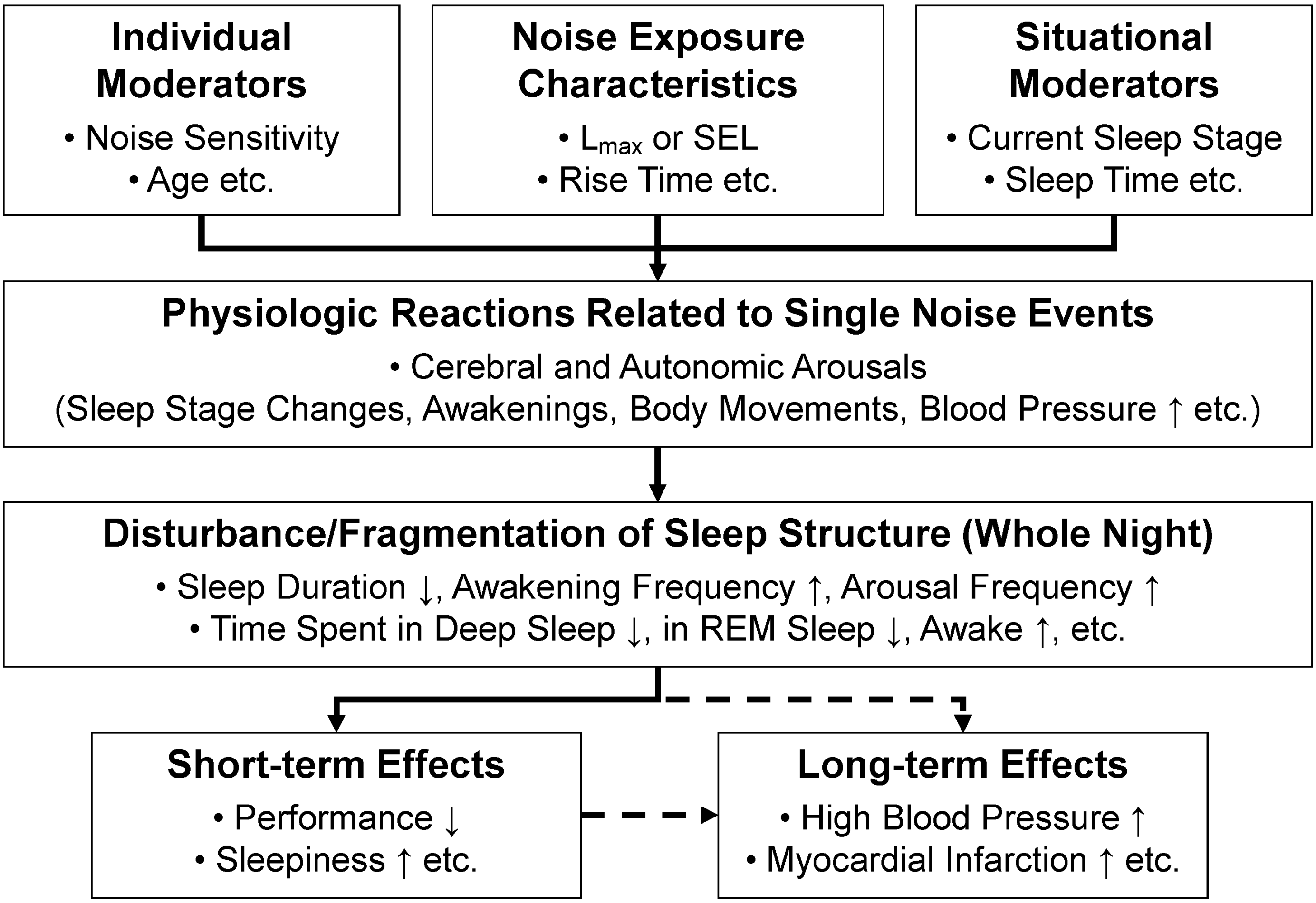
- Physiological awakening or arousals - defined by changes to sleep stages measured by a polysomnograph or an EEG, which the subject may not be aware of at the time or recall the next day, and;
- The onset and degree of "motility" i.e body movements which the subject may not be aware of at the time or recall the next day – typically measured using wrist watch like actimeters.

4.21. Where research is in terms of physiological awakenings measured using polysomnography or an EEG, it should be noted that that typically only around 1 in 12 awakenings is of sufficient duration to become a behavioural awakening. In addition, it should be recognised that physiological awakenings are part of the normal architecture of sleep with on average 24 EEG awakenings occurring at night independent of any noise effects.

4.22. There is clear evidence that chronically disturbed or curtailed sleep is associated with negative health outcomes. Repeated noise related disturbance e.g. due to the maximum noise levels from individual noise events, disrupts sleep quality through changes in the stages of sleep structure, which include delayed sleep onset and early awakenings, reduced deep (slow-wave) and Rapid Eye Movement sleep, and an increase in time spent awake and in the superficial light sleep stages. The short-term effects of noise-induced sleep disturbance include impaired mood, subjectively and objectively increased daytime sleepiness, and impaired cognitive performance. This is summarised in the schematic by Basner et al[14] reproduced below.

FIGURE 3: SCHEMATIC SHOWING THE EFFECTS OF NOISE ON SLEEP FROM BASNER ET AL

[14] Basner, Mathias; McGuire, Sarah. 2018. "WHO Environmental Noise Guidelines for the European Region: A Systematic Review on Environmental Noise and Effects on Sleep" Int. J. Environ. Res. Public Health 15, no. 3: 519.



4.23. It is important to realise that two different types of sleep outcomes have been examined. Self-reported sleep disturbance which is linked to external average metrics such as Lnight; and objective sleep disturbance which uses polysomnography (PSG) to record biophysiological changes that occur during sleep and changes in sleep stages which has been linked to individual noise events such as LAmax. Reports between self-reported sleep disturbance and objective sleep disturbance can differ as individuals are not always aware or recall biological awakenings. Average metrics such as LAeq,T may not be best for assessing noise impacts on sleep disturbance when noise events in the night are intermittent and not continuous or persistent, which means that the same Lnight value can result from differing numbers of events of varying overall level. The two types of sleep disturbance should both be considered and may have different implications for assessment of effects.

4.24. The above shows that at a physiological level sleep disturbance due to noise can occur, although sleep disruption by behavioural awakening may not result. In other words, there are noise impacts on sleep that can be measured by examining changes in EEG patterns or a person's motility, but the person would not necessarily be aware of these impacts and they may not have adverse or significant adverse pathological effects. Therefore, care should be taken to not ascribe significance to impacts on sleep detectable at a physiological level, that may occur or appear to occur because of noise impacts, as they may not reflect significant pathological effects or even the impact of noise (because they are part of normal sleep).

4.25. The distinction between detectable impacts and adverse and significant adverse effects of noise on sleep is highlighted in the Government's Planning Practice Guidance in the table summarising the noise exposure hierarchy where it states that:

- Noise with the "*potential for some reported sleep disturbance*" is an "Observed Adverse Effect" that should be mitigated and reduced to a minimum, and;
- Noise with the "*potential for sleep disturbance resulting in difficulty in getting to sleep, premature awakening and difficulty in getting back to sleep*" is a "Significant Observed Adverse Effect" that should be avoided, and;
- Noise that causes "*regular sleep deprivation/awakening*" is a "Unacceptable Adverse Effect" that should be prevented.

4.26. The relationship between the maximum noise level and number of intermittent noise events and the effects upon sleep has been debated for many years. It is generally accepted however that the smaller the number of noise events, the higher the maximum levels that can be withstood without adverse effects on sleep (up to an upper limit, and providing the metrics that measure the overarching total noise energy level during the overall sleep period e.g. LAeq,T does not exceed a suitable threshold).

4.27. Consequently, the LAmax of noise events plus the number of events can be used as the basis of assessing impact; although this is subject to an upper limit. For example, work[15] which informs the WHO community noise guidelines recommendation that peak noise in bedrooms should not exceed 45 dB LAfMax more than 10 to 15 times per night concluded that "*It will be noted in particular that the tolerance to noise in regard to sleep passes through a maximum value for an optimum number of 10 to 15 flights per night and that beyond 20 to 25 occurrences of noise per night the aircraft need to be very quiet or the dwellings provided with excellent sound proofing*."

4.28. Separate work in the publication "Public health impact of large airports" by the Netherlands Health Council[16], based on data from an evaluation of literature, concluded that a sound exposure level (SEL) of 50 dB(A) at the ear of a sleeping person is the onset point of awakenings. This value corresponds with a maximum noise level event of Lmax around 43 dB(A), assuming that the time taken for the noise level to fall from its peak value to a level 10 dB lower is 10 seconds. In addition, other work[17] has demonstrated that the number of tolerable night noise events ranges from 10 to 15 per night for indoor LAmax noise levels of around 55 dB to 45 dB respectively. More recent work[18] has concluded that whilst "*given a certain equivalent noise level, additional information [i.e. LAmax data] on the overall number of events does not improve the prediction of sleep quality. However, the number of events above LAmax of 60 dB was related to an increase in mean motility, indicating lower sleep quality*."

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[15] Vallet M and Vernet I 1991 Night aircraft noise index and sleep research results. In A. Lawrence (ed.), Inter-Noise 91. The Cost of Noise, Vol. 1, pp. 207-210. Noise Control Foundation, Poughkeepsie, NY, USA.

[16] Gezondheidsraad. Public health impact of large airports. Den Haag: Health Council of the Netherlands, 1999.

[17] Spreng, M. (2002) Corticol excitation, cortisol excretion, and estimation of tolerable nightly overflights. Noise and health. (4) 39-46, and; Basner, M., Samel, A., Isermann, U. (2006) Aircraft noise effects on sleep: Application of the results of a large polysomnographic field study. J. Acoust. Soc. Am. (119) 2772-2784

[18] Janssen SA, Vos H, van Kempen EE, Breugelmans OR, Miedema HM. Trends in aircraft noise annoyance: the role of study and sample characteristics. J Acoust Soc Am. 2011 Apr;129(4):1953-62. doi: 10.1121/1.3533739. PMID: 21476651.

4.29. However, there is also research that indicates impacts of individual noise events on sleep at relatively low maximum noise levels. For example, studies[19] have found that "*the threshold of aircraft noise-induced motility during events is Lmax indoor of 32dBA*". At these levels the probability of increased motility associated with a noise event was found to increase just above the equivalent probability with no noise event taking place i.e. there appeared to be no observed effect below this level. This should be considered in the light of the finding in the same study that the probability of awakening at a LAmax noise level at the ear of around 27 dB was 7.2% and rose to only 18.4% at around LAmax 73 dB.

4.30. The main body of sleep research is consistent with a careful interpretation of the viewpoint set out in the World Health Organisation Guidelines which for the ordinary population is that:

- Impacts on sleep can be detected from relatively low level maximum noise events, however the degree of resulting harm may not be significant.
- 'Effects' on sleep (such as EEG awakenings and sleep stage changes) occur spontaneously in the general population many times per night regardless of any impacts due to noise;
- The smaller the number of noise events, the louder the maximum noise level that can be tolerated without adverse effects upon sleep; subject to an upper limit.
- At relatively low levels e.g. around 45 dB LAfmax when sufficient number of such events take place during the night the adverse effects of individual noise events are likely to be limited to sleep disturbance in the form of changes in sleep state or perhaps some EEG awakenings;

[19] Passchier-Vermeer W. et al. 2002. Sleep disturbance and aircraft noise exposure, Exposure effects relationships, TNO report 2002-027; and, Basner, M., et al. "Aircraft noise effects on sleep: final results of DLR laboratory and field studies of 2240 polysomnographically recorded subject nights." 33rd International Congress and Exposition on Noise Control Engineering (Internoise 2004), Prague/Czech Republic. 2004.

4.31. It normally requires internal noise levels higher than 45 dB LAfmax before significant adverse effects such as behavioural awakenings, difficulty getting to sleep, premature awakening or difficulty getting back to sleep generally occur (and the latest field research on rail and aircraft noise suggest that it requires internal LAmax noise levels of around 65 dB LAfmax before noise induced awakenings become distinguishable from spontaneous awakenings).

4.32. Based on the NPPG Noise Exposure Categories[20], behavioural awakenings are an unacceptable adverse effect on their own as they directly cause sleep deprivation/awakening by curtailing sleep quantity and should be prevented.

4.33. However, disturbance of the sleep cycle that doesn't result in behavioural awakenings can be a significant adverse effect as defined in the NPPG Noise Exposure Categories when such arousals cause sleep disturbance on a regular basis, as this leads to poor sleep quality due to fragmentation of the sleep cycle. Researchers[21] note that "*Although superficially more subtle than total sleep deprivation (TSD), chronic sleep disruption has far-reaching consequences starting from the effects on brain cells and ending with recent insights in the mechanisms involved in the chronically disrupted sleep experienced by people suffering from insomnia, one of the most common disorders. In some cases, negative consequences result from the fragmentation of the normal sleep pattern into short sleep bouts frequently interrupted by brief awakenings, even if the total daily amount of sleep is not decreased*."

4.34. The same researchers go on to say "*The relevance of findings from experimental studies is supported by observational studies on the consequences of naturally occurring sleep disruption, whether due to environmental and societal demands or pathological conditions such as sleep-disordered breathing or insomnia. The resulting insights lay ground for a mechanistic understanding of the epidemiological finding that disrupted sleep contributes to the major*

[20] Paragraph: 005 Reference ID: 30-005-20190722 Revision date: 22 07 2019

[21] Eus J.W. Van Someren, Disrupted Sleep: From Molecules to Cognition, The Journal of Neuroscience, October 14, 2015 • 35(41):13889 –13895

health challenges facing our aging society, including type 2 diabetes, cardiovascular disease, neurodegeneration, and depression.".

4.35. Consequently, as well as assessing the "unacceptable" adverse effect of sleep disruption/deprivation by behavioural/recalled awakenings due to noise, it is also important to consider impacts of noise on sleep quality at noise levels that do not induce behavioural/recalled awakenings but can have significant adverse effects in terms of sleep disturbance by fragmenting sleep due to interference with the sleep cycle on a regular basis.

Direct effects on Health e.g. Cardiac Effects, hypertension, stroke, etc

4.36. Examples of non-auditory direct health effects linked to aviation noise are considered in the following part of this evidence

Severity of Health Effect

4.37. An important concept is that of the severity of the noise effects on health, for example the issue of whether annoyance is "real" health effect.

4.38. Babisch, in a paper in 2002[22] summarised the situation as follows;

"Adverse health effect

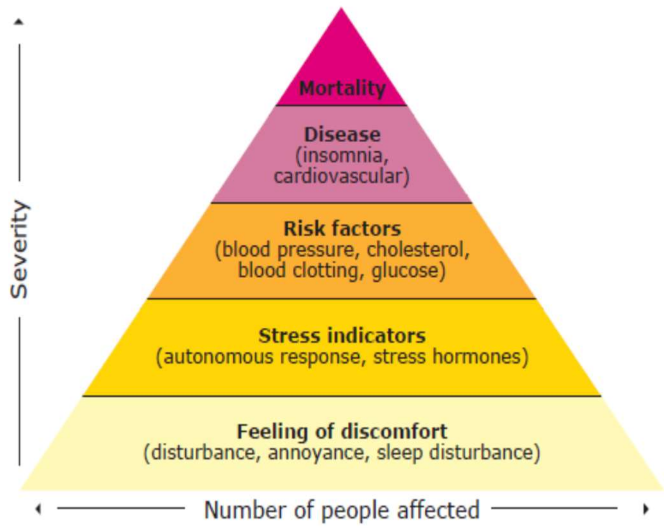
The severity of the health outcome, it's prevalence in the general population, the frequency of exposure considered relevant for health, and the magnitude of effect are important issues in risk impact assessment. The term "adverse" is essential in this context of environmental standard setting. Risk management should ensure that "adverse" health effects cannot occur. Decisions on whether or not any effect is adverse, requires expert judgement. The World Health Organisation defines an "adverse effect" as follows [WHO, 1994]:

[22] Babisch W. The noise/stress concept, risk assessment and research needs. Noise Health. 2002; 4(16):1-11.

"Change in morphology, physiology, growth, development or life span of an organism, which results in impairment of the functional capacity to compensate for additional stress, or increase in susceptibility to the harmful effect of other environmental influences."

4.39. Babisch then uses the following Figure to illustrate the concept. The key message here is that across the population as a whole; the higher the noise level, the more likely severe effects will occur, and less severe effects will affect a greater proportion of the exposed population.

FIGURE 4 - SEVERITY OF EFFECTS AND NUMBERS OF PEOPLE AFFECTED



Source: Babisch, W, 2002[XVII].

4.40. The above work and figure is also referred to and reproduced in the European Environment Agency's (EEA) Good Practice Guide on Noise Exposure and Potential Health Effects (2010).

Cardiovascular and physiological effects

4.41. During the last 15 to 20 years many reviews of a large number of studies and research papers on the health effects of noise have been published. The Civil Aviation Authority routinely has reviewed the increasing evidence of direct effects of aircraft noise on health in the following reports:

- CAP2113 Aircraft Noise and Health Effects: A six-month update (April 2021)
- CAP1883 Aircraft Noise and Health Effects: A six-month update (September 2019 – March 2020).
- CAP1841 Aircraft Noise and Health Effects: A six-month update (April 2019 – September 2019)
- CAP1278 Aircraft noise and health effects: Recent findings (2016)
- CAP1164 Aircraft noise, sleep disturbance and health effects (2014)
- ERCD Report 1208 Aircraft Noise, Sleep Disturbance and Health Effects: A Review (2013)
- ERCD Report 0907 Environmental Noise and Health: A Review (2010)

4.42. All the aforementioned reviews discuss the now substantial body of evidence and research that noise has direct effects on health such as hypertension, stroke and cardio-vascular problems. The reviews also report that the risks direct health effects increase with increasing noise level, although they don't develop a precise dose-response for aviation noise at this time. None of these reviews are referenced in either the noise or human health chapter of the ES or AES.

4.43. There are issues with the way in which population and noise data was gathered for the research reviewed in the CAA reports e.g. how the effects of confounding factors such air pollution and smoking were taken into account, how high noise levels were grouped, and whether and how noise insulation and preference for open windows was taken into account; which militate against using the studies to define precise thresholds of health effects for aircraft noise. But the overall trend i.e. increasing aircraft noise leads to an increased risk of direct health effects and the effect is greater for aviation noise that occurs at at night, are the broad findings of studies in the UK and internationally, and for other noise sources.

4.44. Because of the uncertainties with the research the risk of aviation noise induced cardiac effects does not rise above the "normal" relative risk of 1 until the day time noise levels are greater than around LAeq, 16 hr 63 dB and night time levels exceed approximately Lnight 55 dB. The apparent link between day time and night time aircraft noise and direct health effects below these values can be regarded as comparatively weak and could be due to factors other than noise. Whereas above 63 dB during the day and 55 dB at night the association between daytime and night time aviation noise and direct health effects is stronger and statistically more reliable and robust.

4.45. There is growing body of evidence that aviation noise has cardiovascular effects. The link with higher levels of aircraft noise and exposure at night is strongest[23]. However, defining thresholds at which such effects occur is extremely complex, and the various statistical uncertainties involved in possible associations between noise and cardiovascular health outcomes and the influence of confounding factors need to be considered.

4.46. There is, however, a more practical point which needs to be made in the context of the proposed scheme. Techniques[24] have been developed and have been used to quantify health impacts of various scenarios in terms of numbers of potential cases of cardiovascular disease which might be attributable to noise. Essentially, these make use of the kind of exposure-response relationships found in the published research, together with detailed information on the noise exposure of the affected or potentially affected population.

4.47. However, because of the intrinsically relatively low normal incidence of cardiovascular disease in the general population irrespective of noise exposure such quantitative assessments are only possible on large population sizes i.e. several 100,000s of persons, preferably millions.

[23] E.g. WHO Report: Burden of disease from environmental noise (2011) – conclusions of environmental noise and disease; Thomas Münzel et al, Cardiovascular effects of environmental noise exposure Eur Heart J. 2014 Apr 1; 35(13): 829–836. Omar Hahad et al. The Cardiovascular Effects of Noise Deutsches Ärzteblatt International | Dtsch Arztebl Int 2019; 116: 245–50 | Supplementary material; and Alexandros S. Haralabidis et al Acute effects of night-time noise exposure on blood pressure in populations living near airports, European Heart Journal, Volume 29, Issue 5, March 2008, Pages 658–664.

[24] E.G The WHO report Burden of disease from environmental noise (2011) and WebTAG Unit A3 Environmental Impact Appraisal

Consequently, it would not be possible to make a meaningful quantitative assessment of the risk to the comparatively few persons the AES recognises will be exposed to increases in aviation noise of more 63 dB LAeq,16 hr or the persons the ES recognises will be exposed to aviation noise of more than 55 dB Lnight.

3.5.12 However, based on the various reviews of the evidence, together with the interpretation of more recent individual studies outlined above, it is considered that the risk of cardiovascular effects from aircraft noise starts to become significant at levels above 63 dBA LAeq,16h and 55 dB Lnight.

4.48. Table 6A.13 and table 6A.16 in the AES show that in 2030 the 12MPPA scheme is likely to increase the population exposed to SOAEL values of 63 dBA LAeq,16h and 55 dB Lnight. or higher, by zero persons for the LAeq,16 hr index and by 147 persons for the Lnight metric respectively, compared to 10 MPPA. Consequently, there is an increased risk of direct health effects associated with the 12MPPA scheme.

Childrens' cognitive development

4.49. More than 20 studies have shown environmental noise exposure has a negative effect on children's learning outcomes and cognitive performance[25].

4.50. The 2005 RANCH[26] study in Britain, Holland and Spain published in The Lancet (CD 10.2), found that young children living near airports (including Heathrow) lagged behind their classmates in reading by up to approximately two months for a five decibel increase in aviation noise in their surroundings. The study also associated aircraft noise with lowered reading comprehension, even after socio-economic differences were considered. Follow up work has established that if

[25] Evans G, Hygge S. Noise and performance in adults and children. In: Luxon L, Prasher D, eds. Noise and its effects. London: Whurr Publishers, 2007.

[26] Stansfeld S A, Berglund B, Clark C, et al, for the RANCH study team. Aircraft and road traffi c noise and children's cognition and health: a cross-national study. Lancet 2005; 365: 1942–49; and Clark C, Martin R, van Kempen E, et al. Exposure-effect relations between aircraft and road traffi c noise exposure at school and reading comprehension: the RANCH project. Am J Epidemiol 2006; 163: 27–37

affected children move to locations with less aircraft noise they can catch up and recover any reading age loss.

4.51. In a 2015 review of health effects of noise exposure in children[27] (CD 10.7) researchers comment on the effects of aviation noise on children's cognitive development as follows:

Studies have shown that children exposed to chronic aircraft or road traffic noise at school have poorer reading comprehension and memory than children who are not exposed [11, 30, 35]. A study of 9- to 10-year-old children from rural Alpine areas [36] found that modest levels of ambient community noise (train and road traffic noise above 60 dBA) were associated with poorer memory performance, but not with performance on a test of attention. Several studies have suggested that the effects of noise on children's cognition are not uniform across all cognitive tasks: tasks which involve central processing and language comprehension, such as reading, problem solving and memory appear to be most affected by exposure to noise [37, 38].

Robust evidence for noise effects on children's cognitive performance comes from intervention studies and natural experiments where changes in noise exposure have been accompanied by changes in cognitive performance, such as the Munich Airport study [9, 10, 39]. Prior to the relocation of the airport in Munich, high noise exposure was associated with deficits in long-term memory and reading comprehension in children of 10 years of age. Two years after the airport closed, these cognitive impairments were no longer present, suggesting that effects of noise on cognitive performance may be reversible if noise stops. Furthermore, in a new cohort of noise-exposed children living around the newly opened airport, impairments in memory and reading comprehension developed over the following 2 years. The Munich study remains one of the few longitudinal studies in the field, providing important evidence for a cause-effect relationship between noise exposure and cognitive deficits.

[27] Health Effects of Noise Exposure in Children, Curr Envir Health Rpt (2015) 2:171–178

4.52. The Department for Education has released acoustic design standards for schools. Building Bulletin 93 (BB93) (CD 10.36) sets out performance standards for schools. This document makes clear that the performance standards reported within it apply to new and existing schools[28].

Quality of Life

4.53. As stated in section 4.4.4 above, annoyance due to noise can be regarded as both a health and quality of life effect.

4.54. Aircraft noise dose–response relationships, or exposure–response relationships, describe the effect on a population caused by differing levels of noise exposure (or doses), this is often assessed in terms of how many people or the proportion of the population studied are likely to be affected e.g. highly annoyed or suffer sleep disturbance, at different levels of noise exposure.

4.55. Extensive research into noise annoyance and disturbance over many decades has shown that although average long-term effects can be determined using social surveying techniques by asking a representative sample of a population to rate their individual annoyance on a numerical or category scale such as 'not annoyed', 'a little annoyed', 'moderately annoyed' or 'annoyed very much', these responses tend to be only weakly linked with the degree of sound exposure. This modest correlation reflects very large differences between individuals' reactions to the same noise (due to the modifying non-acoustic factors such as attitude to the noise maker, personality traits, perception of control over the noise and noise sensitivity etc.) rather than any failure of experimental design.

4.56. Figure 4 below shows an indicative chart of the 'percentage highly annoyed' of a sample of a population plotted against noise exposure level based on data from numerous social survey

[28] BB93 Regulatory Framework, Pages 8 and 9.

studies of aircraft noise carried out in different countries. The curve is smooth and there is no specific level that represents a precise threshold at which annoyance starts or at which the proportion of the population reacting negatively makes a step change. The curve approximates an exponential curve with the lowest rate of increasing adverse reaction at low noise level, the rate of increased adverse reactions accelerating at the mid to high levels and the fastest rate of acceleration of adverse reaction at high noise levels.

4.57. Each point in the diagram represents the response of a sample of respondents exposed to a particular level of noise. The curve is a 'best fit' to the scattered data points, and the general shape has been re-confirmed more recently by further research which shows the similar scattering of data points.

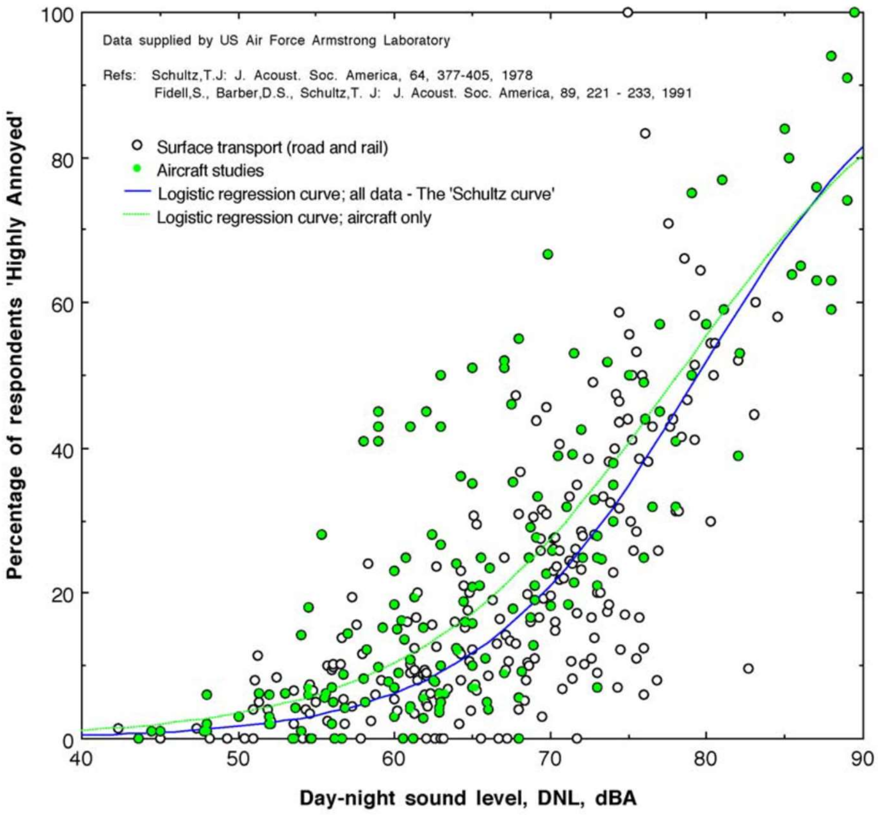
4.58. The purpose of reproducing this chart here is to illustrate how a statistical estimate of the underlying trend between annoyance and the noise index can be developed for a population as a whole, even though the scatter of data i.e. the variability of individual sensitivity is high; as shown by the deviation of individual points from the trend line.

4.59. However, environmental noise assessment is not sufficiently precise, primarily due to the substantial variation in the response to noise across a population, to enable the subjective reaction of individuals to be confidently predicted.

4.60. Consequently, event noise levels and noise exposure contours only provide indications of the likely extent and severity of the general effects of aircraft noise on communities, but due to the significant variability and volatility of individual subjective response to noise, and the significant influence of non-acoustic factors on these traits, they cannot indicate accurately how particular individuals will react.

4.61. Despite these limitations, the curve in the figure below illustrates the probable form of the relationship between noise exposure and community annoyance. It aggregates results from many surveys in different countries and may be considered typical, if not average. The main application of current aircraft noise assessment methodology is in comparing the effects of different noise exposures that might result from changes to an airport and its operations (or between different possible future scenarios).

FIGURE 5 - INCIDENCE OF COMMUNITY ANNOYANCE DUE TO AIRCRAFT NOISE FROM SOCIAL SURVEY DATA



Note: Source of the above figure - CAP 725: CAA Guidance on the Application of the Airspace Change Process Airspace Change Proposal - Environmental Requirements

4.62. Many studies show that the issue of assessment of the impact of aviation noise is complicated by the influence of non-acoustic factors, one[29] of which concluded that in regard to noise management at Heathrow airport: "*Non-acoustic factors in environmental noise can be broadly defined as all those factors other than noise level alone which contribute to noise annoyance and similar effect*s;"

4.63. Consequently, deriving threshold values for the onset of community annoyance and the severity of annoyance above thresholds based on best-fit curves from dose-response studies produces results that reflect the average response across the population rather than of any

[29] Flindell IH, Witter IJ. Non-acoustical factors in noise management at heathrow airport. Noise Health [serial online] 1999 [cited 2021 Jun 15];1:27-44. Available from: https://www.noiseandhealth.org/text.asp?1999/1/3/27/31715 - last viewed 15th June 2021

individual. This will inevitably mean that some persons in the affected communities below the threshold value will be annoyed, and some persons exposed above the chosen threshold will not be annoyed; because although their responses are within the normal range they are not typical. This conundrum is recognised in the APF at paragraph 3.17 which explicitly states that "*We will continue to treat the 57dB LAeq 16 hour contour as the average level of daytime aircraft noise marking the approximate onset of significant community annoyance. However, this does not mean that all people within this contour will experience significant adverse effects from aircraft noise. Nor does it mean that no-one outside of this contour will consider themselves annoyed by aircraft noise*."

4.64. Sections 5 of this proof discuss the how aircraft noise annoyance dose response has been evaluated in the UK and linked to various noise metrics and threshold values.

Tranquillity.

4.65. Much of the area around immediately around the airport and in its vicinity can be characterised as rural in nature interspersed with isolated buildings and dwellings and small settlements; whilst approximately 3.5 Km to the south lies the Mendip Hills Area of Outstanding Natural Beauty (AONB). Excepting the influence of the airport and aircraft traveling to and the airport many of these locations can be broadly ranked as relatively quiet, low in anthropogenic development, rich in natural features and in many places rated as tranquil and peaceful by those who live there and visitors.

4.66. The Government has recognised that a sense of tranquillity contributes to people's enjoyment of the natural environment[30].

4.67. CAA's discusses tranquillity and aviation in the ERCD REPORT 1207 Tranquillity: An overview (2012). The report summary states that "*This report aims to provide an overview of the current*

[30] The natural choice: securing the value of nature, http://www.defra.gov.uk/environment/natural/whitepaper/ (last viewed 20th April 2021)

area and state of knowledge of tranquillity and tranquil spaces within the UK. It forms part of the CAA's activity to support the Department for Transport's objective that the Directorate of Airspace Policy should pursue policies that will help to preserve the tranquillity of the countryside. This overview provides a summary of key research into tranquillity with special attention to aviation."

4.68. The Department of Transport document "Guidance to the Civil Aviation Authority on Environmental Objectives Relating to the Exercise of its Air Navigation Functions" (2014) advises that "*CAA should also take into account the concept of tranquillity when making decisions regarding airspace below 7,000 feet*.".

4.69. The concept of tranquillity is subjective and can be assessed qualitatively. However, several empirical and semi-empirical methods of "measuring" tranquillity have been developed and examples of those that have been use in the UK are discussed below.

4.70. Whilst there is no formal definition of tranquillity there are several in common use e.g. "Tranquillity is the quality or state of being tranquil; meaning calmness, serenity and worry free." [Wikipedia, 2014] and it "is a highly valued yet seemingly elusive experience. It is stimulated by sight, sound and other senses either directly or as a trigger to memories." [Jackson et al, 2007]

4.71. Tranquillity research generally uses similar factors for description of the sound environment as soundscapes, as one aspect to help evaluate or describe the level of tranquillity at a location. Whilst it was mentioned above that it is important for soundscapes to consider non-acoustic aspects such as the landscape or visual aspects, it is particularly essential when describing how tranquil a location is.

Tranquillity Rating Prediction Tool

4.72. The University of Bradford (Watts et al.[31]) have looked at developing a Tranquillity Rating Prediction Tool (TRAPT). The tranquillity rating is a score between 0 and 10 where 0 is 'not at all tranquil' and 10 is 'most tranquil'.

4.73. The TRAPT initially used a measure of the noise level (LAeq,T) and the percentage of natural features (excluding sky) within the scene (NF). An equation was derived through experiments surveying subject's subjective responses in controlled scenarios. It was found, however that there was not sufficient correlation between the predicted tranquillity score and the actual tranquillity score (from subjective experiment). The primary reason identified was that certain man-made cultural and contextual features can contribute to the perception of tranquillity. These features include heritage assets such as listed buildings, religious and historic buildings, landmarks, monuments, and man-made elements of the landscape that that are geographically and aesthetically in keeping with the surrounding environment.

4.74. The TRAPT was revised, therefore to use the percentage of NCF (natural and contextual features) in a scene rather than purely natural features. The tool was further revised as additional moderating factors (MF) are taken into account such as masking of anthropogenic noises e.g. from road traffic with natural sounds e.g. running water, which may increase the tranquillity, or the addition of litter to the scene; reducing the tranquillity. The TRAPT equation is given below.

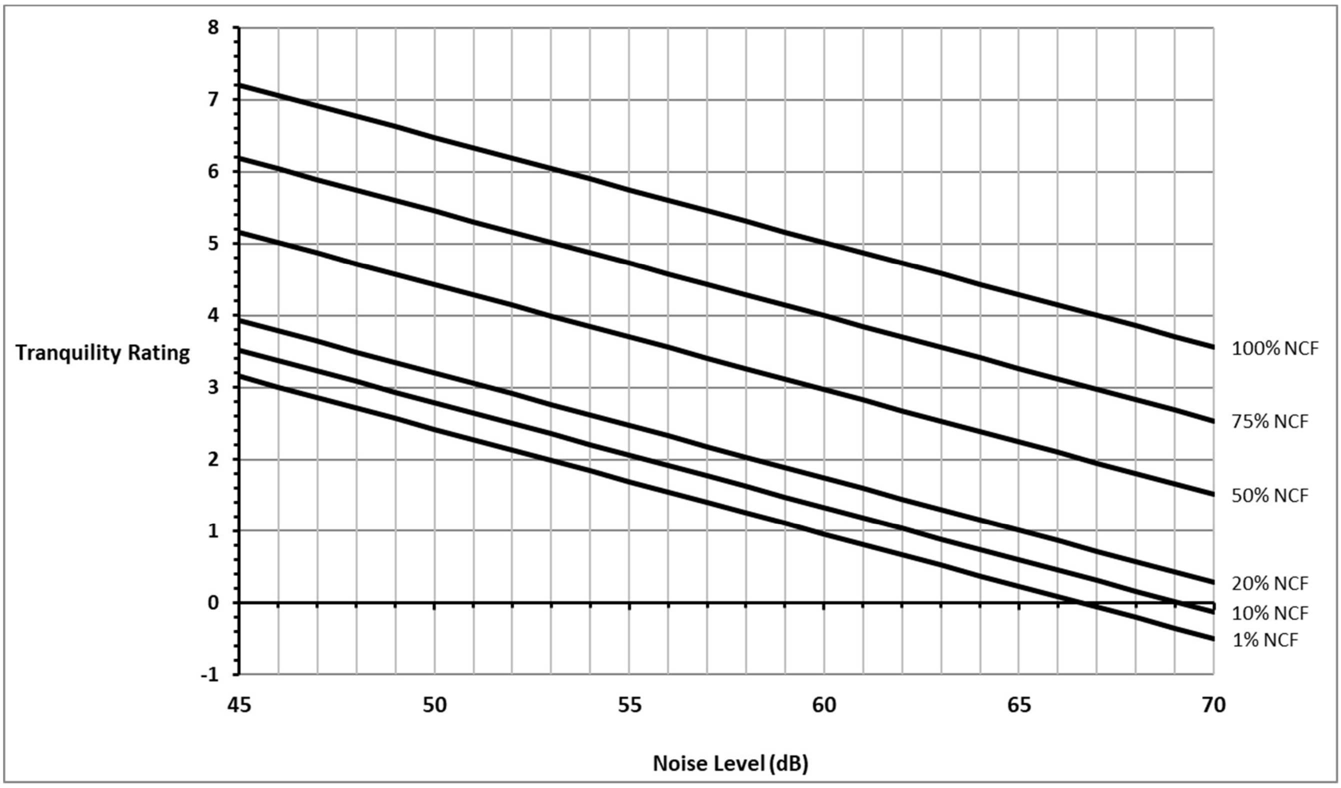
Equation 1: $TR = 9.68 + 0.041\ NCF - 0.146\ LAeq + MF$

The equation shows that for fixed levels of natural and contextual features an increase in the noise level will lead to a decrease in the tranquillity rating. With higher noise levels, of approximately 65 dB LAeq,T or higher, the tranquillity rating is around 4 or lower, so there is

[31] Watts G R, Pheasant R J, Horoshenkov K V, 2010, "Validation of tranquillity rating method", Proceedings of the Institute of Acoustics and Belgium Acoustical Society: Noise in the Built Environment, Ghent, Belgium.

effectively a limit to how tranquil a scene may be when subjected to high noise levels, except with the addition of moderating factors.

FIGURE 6: EQUATION 1, TRANQUILLITY RATING PREDICTION TOOL (TRAPT). THE TRANQUILLITY RATING IS A SCORE BETWEEN 0 AND 10 WHERE 0 IS 'NOT AT ALL TRANQUIL' AND 10 IS 'MOST TRANQUIL'.



Campaign for the Protection of Rural England (CPRE) Tranquillity Mapping

4.75. In 2006 CPRE commissioned a project to map tranquillity on a national scale. The maps were derived by giving a tranquillity score to each 500m by 500m grid square that the land was broken into. The tranquillity scores are derived from the individual relative tranquillity scores of 44 different factors which influence the overall tranquillity scoring (21 positive factors, 23 negative factors). The scores from each factor are weighted and added together for each square to give an overall relative tranquillity score for the grid square. The different factors are split into seeing and hearing various factors, some positive and some negative. Positive factors include seeing lakes or trees in the landscape and hearing running water or no human sounds. Negative factors include seeing roads or wind turbines and hearing low flying aircraft or non-natural sounds. The weighting for each factor was derived through questionnaires whereby people would rate each factor as either positive or negative to the tranquillity at the location.

4.76. Interestingly, seeing villages and scattered houses is a negative attribute for the purposes of CPRE tranquillity mapping, however should they be in the right context; the TRAPT study would treat them as positive to the tranquillity rating.

4.77. The research is useful as it highlights which factors are more important to others in maintaining a tranquil location. For example, 'seeing a natural landscape' (positive) is weighted as 6.59% of the tranquillity score and 'Hearing, Constant noise from cars, lorries and/or motorbikes' (negative) is 10.96% of the score, whilst 'Seeing, Villages and Scattered Houses' is negative but only weighted 0.06% of the score.

4.78. As described above, the soundscape can be important to understanding the cultural characteristics of a place, and therefore can be important to understanding the significance heritage in heritage terms. Soundscape and tranquillity research provide a useful list of factors which help describe the sound environment and attempts to weight those factors to describe which are more important to people than others. The tranquillity research is also helpful as it illustrates that man-made features within a landscape, particularly heritage features, can add to the tranquillity rating of a location and that the introduction of certain types of noise can be detrimental to the positive soundscape required for tranquil conditions.

Soundscapes

4.79. Soundscapes can be defined as follows: "*the sound environment in context perceived by an individual, a group or a society*" [Kang, 2009[32]].

4.80. Kang, 2010[33] provides a summary of soundscape research and notes regarding the effect of soundscape on culture that "*soundscape is a significant factor in the 'sensing of places'*." The study notes that the introduction of more uniform sounds across different society's cities and landscapes leads to more similar sound environments whereas previously there may have been variation which would have helped distinguish and characterise places and show the diversity of cultures. Soundscape studies can help understanding how this aspect of culture may be changing and allow the conservation and restoration of the sound environment.

4.81. Five main issues are considered [Kang, 2010] within soundscape research:

- Understanding and exchanging: This encompasses defining what a soundscape is, evaluating it, describing it and potentially modelling it (in order to predict changes).
- Collecting and documenting: Surveys which can include 'soundwalks' whereby someone walks through a soundscape and then after a period of time answers a series of questions.
- Harmonising and standardising: it will be important to standardise how soundscape definition, evaluation, surveys etc. are completed in order to promote more widespread use and understanding.

[32] Report on the COST Edinburgh workshop on Hot topics in Soundscapes. ISO?TC43/SC1/WG54 Meeting, Seoul, Korea; Kang J. and Management Committee.
[33] Soundscapes where are we?, Kang .J : Proc of Institute of Acoustics & Belgian Acoustical Society – Noise in the Built Environment, Ghent, 2010

- Creating and designing: production of the tools and guidance on soundscapes.
- Outreaching: promoting the outputs and methods to policy makers and general public.

4.82. Key to soundscape research is understanding how the sound environment within its proper context affects its users. The interaction between acoustic and other physical environments is an essential consideration, and of various physical conditions the aural-visual interactions have been intensively studied. Although considerable work has been carried out in the evaluation of soundscapes, it is recognised that there is a need for further work; in particular there is quite a variation in how soundscapes are described and evaluated currently. A soundscape may be described in terms of 'designable' factors, these can essentially be broken down into four factor 'types' [Zhang and Kang, 2007[34]]:

- **Individual sound sources** (such as traffic, birdsong etc.) – these can each be described in terms of sound level, frequency spectrum (or tonality), temporal conditions (time of day, duration, impulsiveness), location and movement (i.e. is the source moving) and psychological / social characteristics (such as it's positive or negative meaning, natural or anthropogenic sound, relationship to activities etc.)
- **Effect of the space** – the characteristics of the space (such as reverberation times and acoustic reflection patterns) in which the soundscape is experienced can affect the perception of the sound sources.
- **Social aspect** – An individual 'user' of the soundscape can perceive it differently due to their social (cultural) or demographic characteristics or their typical acoustic conditions in everyday life (at home, at work) and other previous experience.

[34] A systematic approach towards intentionally planning and designing soundscape in urban open public spaces. Kang. J. Proc of the international Congress on Noise Control Engineering, Istanbul, Turkey, 2007

- **Other aspects** – this can include temperature, humidity, lighting, visual and landscape characteristics, for example.

4.83. Regarding the social aspect, it has been suggested [Bruce et al. 2009[35]] that soundscapes can lead to issues of distraction when it does not conform to a user's perceived sense of normality (expectations) or interferes with listening. Expectation is shown to be an important factor in the users rating (positive or negative) of a soundscape.

Natural Tranquillity Method

4.84. The recently developed Natural Tranquillity Method[36] provides a method which includes elements of soundscaping and quantitative measures to determine the extent to which an area may need to be protected because of its tranquillity and the level of potential harm which could occur if a proposed development was to go ahead.

4.85. Using the Natural Tranquillity Method, a trained person (the assessor) can survey and map an outdoor area for tranquillity. The outcome will demonstrate how tranquil someone would experience the place to be when their assessment is objective and uninfluenced by any pre-existing familiarity with it i.e., they haven't been there before.

4.86. There are four parameters underpinning the Natural Tranquillity Method — NAMM, PONS, LRR and LAT.

4.87. NAMM – is a number between 1 and 5 representing the proportion of natural and man-made sounds as shown below:

- NAMM = 1 All or virtually all sound is from man-made sources

[35] Expectation as a factor in the perception of soundscapes; Bruce, NS, Davies, WJ, and Adams, MD; Euronoise 2009, 26-28 October 2009, Edinburgh, U.K..
[36] Clive Bentley, Tranquil Spaces: Measuring the tranquillity of public spaces, 2019, Sharps Redmore

- NAMM = 2 Sounds are mainly from man-made sources but natural sounds are also present
- NAMM = 3 Natural and man-made noise sources contribute equally to the overall sound level
- NAMM = 4 Sounds are mainly from natural sources but man-made sounds are also present
- NAMM = 5 All or virtually all sound is from natural sources

4.88. PONS is the percentage of time when only natural sounds are heard. Silence (or absence of man-made and natural sounds) is considered a 'natural sound', so it contributes to the PONS value.

4.89. LRR is the contribution of road and rail noise to the tranquillity score. Rail noise must be reduced by 6dB for this parameter and, when both are present, they should be added together (logarithmically). Aircraft noise will often vary considerably over a wide study area and therefore, it is necessary to record the contribution from aircraft to the NAMM and PONS separately and then, at the end of the survey, to add their impact back in over the site as a whole.

4.90. LAT is the overall average ambient sound level (which may be modified in certain circumstances). Generally, it will be the same as the measured LAeq parameter.

4.91. After researching the relevant background details and gaining a good understanding of the site and surroundings, the assessor surveys the area and records the values of the four parameters for each survey location. The assessor records all other relevant data needed to assist with post processing, in line with the guidance in Tranquil Spaces. Once the collected data has been processed and moderated, the calculator can be used to predict the tranquillity score for each location. The output will be a numerical score and description.

Tranquillity Score

Score	Description
1	Frantic / chaotic / harsh
2	Busy / noisy
3	Unsettled / slightly busy
4	Not quite tranquil
5	Just tranquil
6	Fairly tranquil
7	Good tranquillity
8	Excellent tranquillity
9	Perfect tranquillity

4.92. The assessor creates a map of the area showing the tranquillity score at each survey location and produces tranquillity contours from this. This provides a baseline tranquillity map of the area of interest.

4.93. When the impact of a proposed development or design is being considered, the predicted noise levels from this need to be added to the baseline data collected, the NAMM, PONS, LRR and LAT adjusted. Then a new tranquillity map can be produced so that the changes likely to occur can be reviewed.

4.94. For reliable results, it is essential that data is collected and processed as described in Tranquil Spaces. The neighbourhood tranquillity should also be considered when interpreting the output.

4.95. The method is designed to predict the responses of someone who is both objective and uninfluenced by any pre-existing familiarity with the place. Those who regularly visit a location will often give a more positive response, due to the subconscious bias which happens when someone has an attachment to a location.

4.96. Even relatively small sites will have variations in tranquillity scores within them and locations such AoNBs will have substantial variability in the tranquillity scores. To determine whether tranquillity should be protected when considering a planning application, it is helpful to understand the how existing tranquillity scores vary within a site or across a location. Also, since tranquillity is perceived relative to the area around it, understanding neighbourhood tranquillity will be important. For these reasons, it is best to report tranquillity scores using a map of the site and its surroundings. The primary output from the Natural Tranquillity Method is generally a tranquillity map. The ES and AES are silent on the issue of tranquillity and how the proposed scheme might impact and adversely affect tranquillity in the locality of the airport, nearby rural areas and the Mendip Hills Area of Outstanding Natural Beauty (AONB) only a few kilometres to the south of the airport.

Consideration of Tranquillity in the ES and AES

The potential spatial scope for further erosion of tranquillity by the increased numbers of aircraft of varying degrees of noisiness due to the 12MPPA scheme can be qualitatively estimated from looking at the figures below from the Bristol Airport document "living near the airport - where aircraft fly"[37]. These figures show flights paths for aircraft using the airport, the numbers of aircraft and their heights, and the areas including the Mendips AONB that were overflown by aircraft, in 2014.

FIGURE 7: IMAGE FROM THE BRISTOL AIRPORT DOCUMENT "LIVING NEAR THE AIRPORT - WHERE AIRCRAFT FLY"

[37] See https://www.bristolairport.co.uk/~/media/files/brs/about-us/living-near-the-airport.ashx?la=en (Last viewed 19th April 2021.

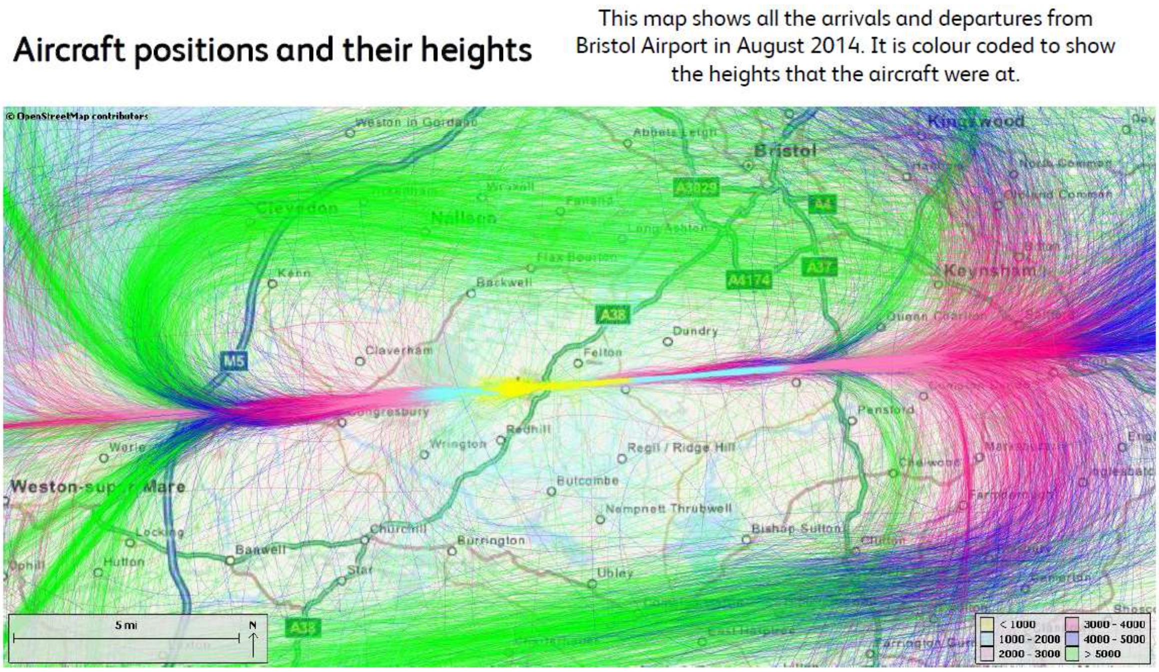
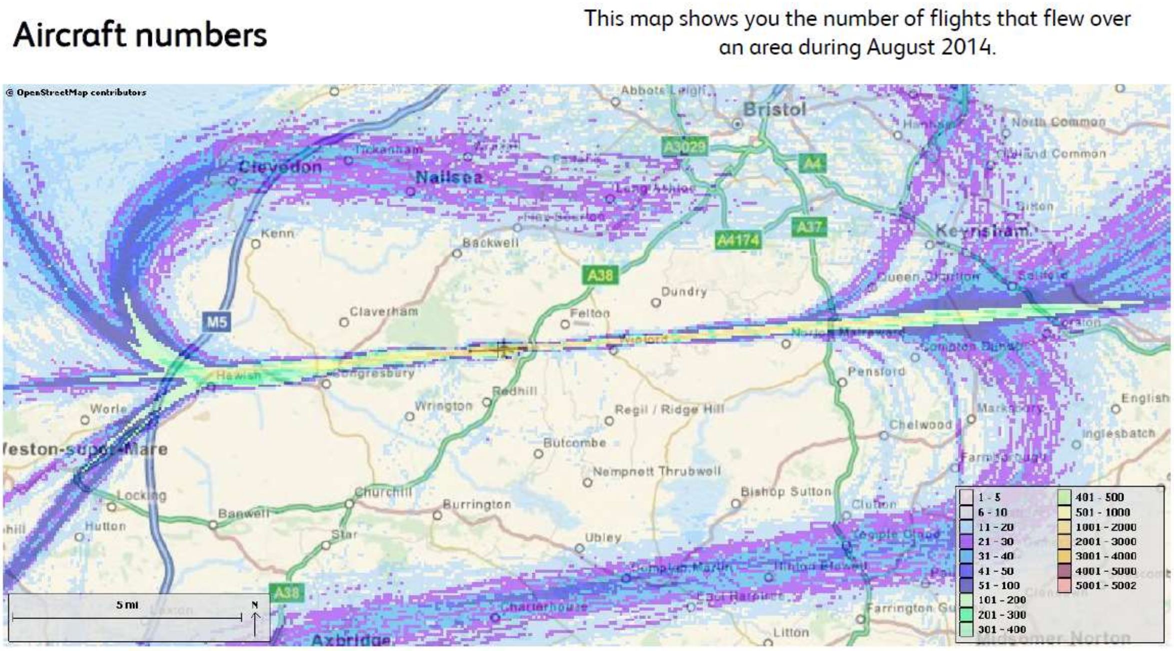


FIGURE 8: IMAGE FROM THE BRISTOL AIRPORT DOCUMENT "LIVING NEAR THE AIRPORT - WHERE AIRCRAFT FLY"



4.97. The figures above indicate that a considerable area is overflown by aircraft using Bristol airport below the 7000 ft altitude cut off the Department for Transport recommends for consideration of the concept of tranquillity for air space changes. However, the ES and AES present no assessment of the effects of the proposed scheme on tranquillity.

4.98. At first sight the modest increases in noise assessed using the LAeq,16 metric predicted in the ES and AES appear unlikely to indicate a significant adverse effect on tranquillity, which in the rural and small settlement locations where aircraft fly below 7000 ft is already most likely compromised, to varying degrees depending on distance from the airport, by the existing operation of the airport. But this approach misses the potential effects of the increase numbers of in day time ATMs to achieve the 12 MPPA target compared to 10 MPPA in 2030, and that each one of these additional ATMs could individually be either no quieter than currently or less noisy by a degree that would range from not being perceptible to not being valued (see paragraphs 7.46 and 7.47 of this evidence). It is therefore considered inevitable that the tranquillity of locations in the rural and small settlement locations where aircraft fly below 7000 ft, which includes a significant proportion of the northern part of the Mendip Hills AONB, as indicated in the images above will be eroded to a greater degree than if the scheme did not go ahead.

5. DOSE RESPONSE STUDIES

5.1. As noted in the previous section dose responses studies can be used to establish typical community response to noise e.g. the percentage of the exposed population annoyed or highly annoyed by aircraft noise

5.2. The following sections of this evidence discuss how dose response for aviation noise have been developed in the UK.

Previous Studies

5.3. Following the recommendations of the Wilson Committee report on noise in 1963, the descriptor chosen for predicting and monitoring aircraft noise at Heathrow Airport was the Noise and Number Index, NNI, which is based upon the Perceived Noise Level, in PNL dB, of each aircraft type and the number of that type operating into and out of the airport.

5.4. After a survey in 1967, the Number was defined as the number of aircraft exceeding a Noise of 80 PN dB during the 12-hour period from 06:00 to 18:00 GMT (07:00 to 19:00 BST) averaged over the summer period from mid-June to mid-September. Consequently, NNI was a long-term average over the summer period. Meteorological conditions and airport operation may cause the short-term noise exposure at particular points over briefer intervals to be different than in this specified period; but use of this summer period has become a standard approach in assessment of noise impacts from airports.

5.5. Given information about aircraft types and a timetable of arrivals and departures, it is possible to predict NNI levels around an airport. Maps showing contours at 5 NNI intervals from 35 NNI upwards were produced for the major airports.

5.6. The Wilson Report found that:

- 35 NNI relates to low levels of community annoyance,

- 45 NNI to moderate levels of community annoyance; and,
- 55 NNI to high levels of community annoyance.

5.7. It is important to understand that the above relates to "community annoyance" i.e. the response of a population, and that within the group exposed to aircraft noise at these levels there will be a wide variability in individual subjective response. For example, some individuals would be annoyed at NNI of less than 30, and others might not be annoyed at NNI of 55 or over.

5.8. However, continued use of the NNI went against the international trend to use LAeq,T; and there were problems in establishing compliance, as NNI cannot be measured directly and has to be calculated from the relatively complex Perceived Noise Level of each aircraft. Additionally, unlike LAeq,T the NNI was not easily comparable with other national systems and was really only valid for Heathrow for which it was formulated. Also, it ignored all noise events that are imperceptibly under 80 PNL dB, and it makes no allowance for the duration of individual noise events or for the degree to which noise levels exceeds 80 PNL dB.

5.9. In order to address issues with the use of NNI the United Kingdom Aircraft Noise Index Study (ANIS), undertaken in 1982, was commissioned by the Department of Transport. The study and its findings were published by the Directorate of Research of the Civil Aviation Authority in 1985 as DR 8402 - United Kingdom Aircraft Noise Index Study. Areas, each approximately 1km2 were identified for surveying: 18 in the vicinity of Heathrow; 2 at Gatwick; and one each at Aberdeen, Luton and Manchester airports.

5.10. The survey used the Guttman Annoyance Scale (GAS) and found that LAeq,24h had a slightly better correlation than NNI with perceived annoyance/disturbance averaged over the period mid-June to mid-September.

5.11. In 1986, the Department of Transport undertook a consultative exercise involving all interested parties such as: Local Authorities; airport operators; airline companies; Members of Parliament etc. Responses and comments appeared in the DORA Report 9023 'The use of Leq as an Aircraft Noise Index' (1990). The DORA 9023 report can be viewed at:

5.12. The ANIS report had previously established the relationship between NNI and LAeq,24h to be:

- 35 NNI is equivalent to 57 dB LAeq,24h (low levels of community annoyance)
- 45 NNI is equivalent to 63 dB LAeq,24h (moderate levels of community annoyance)
- 55 NNI is equivalent to 69 dB LAeq,24h (high levels of community annoyance)

5.13. Based on the findings of the ANIS and the DORA 9023 reports the following impact assessment criteria were proposed:

- 57 dB LAeq,24h (low levels of community annoyance)
- 63 dB LAeq,24h (moderate levels of community annoyance)
- 69 dB LAeq,24h (high levels of community annoyance)

5.14. However, it was felt that LAeq,24h would be too radical a change from the 12-hour basis of NNI and therefore the following indices were proposed:

- LAeq,16h for 07:00 to 23:00 (day)
- LAeq,8h for 23:00 to 07:00 (night)

5.15. These periods aligned with those in PPG 24 – the then current ministerial advice on planning and noise.

5.16. In correlation with PPG24, it was then proposed that these criteria were referenced over the following time periods:

- 57 dB LAeq,16h (low levels of community annoyance)
- 63 dB LAeq,16h (moderate levels of community annoyance)
- 69 dB LAeq,16h (high levels of community annoyance)

5.17. The more recent ANASE study (2005) showed a stronger response to aviation noise than the rather elderly ANIS study and the Aviation Policy Framework recognised this increased sensitivity; the APF describes an aviation noise level of 57 dB LAeq,16 hr as being the "*approximate onset of significant community annoyance*" and that some persons exposed below this value will consider themselves annoyed and some persons exposed above this value will consider themselves annoyed. This equivocation about the precision of the 57 decibel threshold for the onset of community annoyance reflects the evidence that the subjective response to aviation noise has increased; but knowledge of how aircraft noise affects people was still not sufficiently precise, primarily due to the substantial variation in sensitivity to noise across a population, to enable the subjective reaction of individuals to be confidently predicted. Consequently, event noise levels and noise exposure contours only provide indications of the likely extent and severity of the general effects of aircraft noise on communities, but due to the significant variability and volatility of individual subjective response to noise, and the significant influence of non-acoustic factors on these traits, they cannot indicate accurately how particular individuals will react. As a result, some persons will be annoyed by aircraft noise at levels lower than 57 decibels as their reaction is part of the normal range; albeit it may not be typical.

S0NA14

5.18. The Survey of Noise Attitudes (SoNA) 2014 (CD 10.9) is the most recent major attitudinal survey on aviation noise conducted in England.

5.19. The SoNA14 report describes a research study to obtain new and updated evidence on attitudes to aviation noise around airports in England, and how they relate to the UK aircraft noise exposure indices. The study was commissioned by the Department for Transport and builds on earlier noise attitude surveys commissioned by Defra.

5.20. As described above the 57dB LAeq,16h contour was chosen as the threshold of community annoyance because it 'indicated a marked increase in some reported measures of disturbance', with 63 and 69dB LAeq,16h representing medium and high annoyance and subsequently incorporated into planning policy guidance.

5.21. However, critics of the LAeq,16h metric argued that:

- it is difficult to comprehend, being on a logarithmic scale, and;
- an equivalent continuous level is not consistent with people's perception of aircraft noise as a number of discrete, noticeable events, and;
- it is out of date, 57 dB LAeq,16h no longer represents the approximate onset of significant community annoyance.

5.22. The SONA 14 study found the following:

- LAeq,16h is still an appropriate indicator to use to estimate the annoyance arising from aircraft noise; and there was no evidence that other indicators such as N65/70 or Lden performed better,
- The summer day, average mode, was an appropriate period to use as opposed to single-mode, although easterly single mode was better correlated with subjective response compared to the summer average mode.

- Mean annoyance score and the likelihood of being highly annoyed were found to increase with increasing noise exposure (LAeq,16h). The relationship found was close to linear, though annoyance levels plateau at low exposure and do not reach zero annoyance.
- Annoyance scores were found to be comparable with those found for the ANASE restricted sites, but lower than found by the full ANASE study, and higher than found by ANIS.
- For a given noise exposure, a lower proportion of respondents was found to be highly annoyed than compared with ANASE, the results of which were considered unreliable.
- For a given noise exposure, a higher proportion of respondents was found to be highly annoyed than compared with ANIS.
- The same percentage of respondents said by ANIS to be highly annoyed at the threshold of 57 dB LAeq,16h which the APF says marks the onset of significant community annoyance now occurs at 54 dB.
- Evidence was found that non-acoustic factors such as noise sensitivity, approximated social grade, and expectations – both prior to moving to an area exposed to aircraft noise and in the future – influence reported aircraft noise annoyance and these non-acoustic factors may be as important as the noise exposure level.
- An indication was found that urban/rural classification may be a non - acoustic factor, however, this was confounded by approximated social grade and the presence of double-glazing.

ISSUES WITH DOSE RESPONSE STUDIES AND DERIVED THREOHOLDS

ICCAN comments on SONA14 study

5.23. The Independent Commission for Civil Aviation Noise (ICCAN) published a review of SONA14. in December 2019 (CD 10.37). This review made several recommendations regarding future studies of the UK population response to aviation noise based on lesson learned from the SONA study.

5.24. The ICCAN review clearly states that it has not set out to conduct a full or critical review of SONA14 but instead seeks to 'learn lessons' to help guide future work in this area. However, it implies that the approaches taken in delivering SONA14 may have underestimated the impact of aircraft noise on annoyance in particular localities, although whether the response to aviation noise in these areas is typical is not considered.

5.25. The ICCAN review makes the following recommendations:

- a new, regular attitudinal survey towards aviation noise is begun, with the first of the series conducted before the end of 2021.
- that this new survey is run and analysed independent of Government, regulators and industry.
- ICCAN will look into a sustainable solution to funding the surveys, involving government and industry.
- ICCAN recommends that lessons learned from SoNA are used to make improvements for the new attitudinal survey in the following areas:
    - Scope of population sampled
    - Survey mode
    - Sampling
    - Questionnaire used

- Time series (e.g. regularly repeated)
- Survey costs
- Compatibility with historical UK surveys and international studies.

The Change Effect and Cross-Sectional studies

5.26. By convention community response to a change in transport noise has typically been predicted by using data from existing dose-response curves based on cross-sectional[38] studies surveying separate people's responses to different levels of noise[39] . However most, if not all, of these studies were conducted at sites at which the prevailing noise environment had changed little over preceding years. Exposure-response curves derived from these studies therefore reflect human response to noise in situations of steady-state, constant or unchanging noise exposure. Despite this limitation, the results of these types of study are used extensively in noise impact assessments, to estimate likely response of a population experiencing a change in noise exposure.

5.27. However, there are now a significant number of studies which have examined human response where there has been a step change, or abrupt change, in noise exposure. The results suggest, though not invariably, that the actual response may be different where there has been an increase or decrease in level, to the response predicted from steady-state curves[40]. All available studies demonstrate an excess response in situations of both increments and decrements of

[38] A cross-sectional study involves looking at people who differ on one key factor at one specific point in time. The data is collected at the same time from people who are similar in other characteristics but different in a key factor of interest such as noise exposure. Crucially, cross-sectional studies do not include surveying before and after any change in the factor of interest.
[39] E.g. The SONA14, ANIS, ANASE and the studies underlying the Environmental Noise Guidelines for the European Region (2018) are all cross-sectional studies of population responses to aircraft noise at a point in time and do not include consideration of responses before and after change.
[40] E.g. Fidell et al, Community Sensitivity to Changes in Aircraft Noise Exposure, NASA Contractor Report 3490, 1981; Raw & Griffiths The effect of changes in aircraft noise exposure, Journal of Sound and Vibration (1985) 101(2),273-275; Brown & Van Kempen, Response to a change in transport noise exposure: A review of evidence of a change effect, J. Acoust. Soc. Am. 125 (5), May 2009 and Schreckenberg, et al (2016). Effects of aircraft noise on annoyance and sleep disturbances before and after expansion of Frankfurt Airport – results of the NORAH study, WP 1 'Annoyance and quality of life'. Proceedings of the INTER-NOISE 2016, 45th International Congress and Exposition on Noise Control Engineering. (pp. 7768-7777). Hamburg, Germany, August 21 – 24, 2016.

noise exposure: more respondents whose noise exposure has increased report annoyance than expected from steady-state studies; fewer respondents whose noise exposure has decreased report less annoyance than expected from steady-state studies. The effect is present even for quite small changes in noise exposure.

5.28. In other words, human response to change in noise exposure may include a change effect as well as an exposure effect. With the change effect being an excess response in addition to the exposure effects that persist in the long term, so that in the short to medium term the proportion of a population reporting adverse effects after a change in noise is often greater than when comparing two different groups of persons in the otherwise same population simultaneously subject to noise levels equivalent to the prior to and post change values.

5.29. The classification of noise change is important as the degree of associated change effect is usually different, albeit the exposure effect is similar.

5.30. The types of change in noise have been characterised[41] as follows:

"*A step change in noise exposure may occur through different mechanisms. Type 1 changes result from a new or eliminated source, or change in intensity of the source (changes in traffic flow rates, road bypass construction or change in runway configurations, for example). Type 2 changes result from some (usually noise path) mitigation intervention. In Type 2 changes, there are no changes in the transport source flow rates or source noise emissions, just in exposure of the respondents (for example, the erection of barriers along roadways or railways).*

Dimensions of the change in exposure include the direction of the change - increase or decrease; the magnitude of the change; and whether the change is a step change or whether it is gradual; and if gradual the rate of change. Some noise exposure changes may be temporary (such as shutting a runway for maintenance) whereas others are permanent."

[41] Brown & Van Kemp, Estimating the magnitude of the change effect, 9th International Congress on Noise as a Public Health Problem (ICBEN) 2008, Foxwoods, CT

There could also be a Type 3 change[42] in which an individual may relocate from one dwelling to another that has a different noise exposure. While this, equally, is a step change in noise exposure, this type of change does not appear to be reported in any studies so far.

5.31. The reasons for the change effect excess response have been postulated and discussed as follows[39]:

A. Any change effect is only transient as people adapt to the change – "*Overall, there is no evidence that the change effect is a transient phenomenon*".

B. Respondents' anticipation or expectation of change – "*If certain attitudes do change in situations where noise exposure changes, the role of expectation may partly be to shift the occurrence of attitudinal change, temporally, to before the change in exposure*".

C. Respondents' attitudes toward the source/authorities change – "*Despite strong evidence Breugelmans et al. (2007) that changes in negative attitudes cannot explain observed excess response, the emphasis that has been given to this explanation in the past suggests that it should perhaps not be rejected at this stage without further confirmation.*"

D. The combined effects of changes in other environmental attributes an area effect or a halo effect, though we prefer the term surrogate effect – "*The surrogate effect explanation remains a plausible mechanism to explain excess response*" E.g. a noticeable increase in number of flights leads to a greater adverse impact than just the associated change in noise on its own, particularly if the additional individual flights are not substantially less noisy.

E. Demand-response bias generated by repeated questioning of respondents – "*The evidence suggests that demand response bias generated by repeated questioning is unlikely to be the cause of observed excess-response change effects*".

[42] Brown & Van Kemp, Response to a change in transport noise exposure: A review of evidence of a change effect J. Acoust. Soc. Am. 125 (5), May 2009.

F. Found in adaptation-level theory i.e. Respondents who are chronically exposed to high levels of noise would become desensitized to the exposure, experiencing reduced effects. – "*Adaptation-level theory can be discarded as an explanation for excess response*".

G. Partial retention of behavioural coping strategies –"*The retention of behavioural coping strategy explanation has not been subjected to further testing but, based on the limited evidence, remains a plausible explanation of the change effect*".

H. Differential response criteria (response bias) in responding to annoyance scales – "*Researchers invariably assume that response criteria for annoyance scales, or personal decision criteria are the same across all respondents irrespective of their exposure….. but it has been demonstrated that response criteria for annoyance scales are not independent of the noise condition i.e. when chronically exposed respondents experience a change, they may expand the annoyance scale to cover more of the range of the noise effect dimension, adopting post change response criteria for the annoyance scale*" .

I. Memory distortion – "*as most studies in which a change effect has been observed have not used retrospective assessments, they can be discarded as an explanation of the change effect*".

J. Self-selection i.e. studies are biased because noise sensitive people move away from the noisy locations studied –"*There is no convincing evidence supporting this explanation*".

K. Perceptual constancy i.e. people respond according to their perception of the source levels of the noise rather than to what they experience after the noise levels have changed – "*While not explaining the change effect itself, perceptual constancy or loudness constancy may explain differences between type 1 and type 2 changes.*".

5.32. There are far fewer longitudinal studies of changes in aircraft noise from which the excess response of the change effect can be determined compared to the many more cross-sectional studies that are used to approximate the steady-state response. Consequently, reliably estimating the likely magnitude of any excess response to changes to aircraft noise is subject to substantial uncertainty.

5.33. Studies of both Type 1 and Type 2 changes in aircraft noise have been carried out, and there is some evidence that people may respond differently in Type 2 changes, reporting less excess response and little or no change-effect[43].

5.34. Regarding the duration of any change effect researchers[44] have commented as follows:

"*Only a small number of recent studies contributed data tracking respondents' reactions for an extended period after the change. Griffiths and Raw (1987, 1989) extended a previous longitudinal study of response to reduced traffic noise (Griffiths and Raw, 1986). They found that some 40% of the large excess response to change they had originally measured 2 years after the reduction was still present 7–9 years after the change. Moehler et al. (1997) showed that annoyance reductions achieved by noise reductions through rail grinding still persisted in a third survey, 12 months after the initial survey following the noise reductions. Klæboe et al. (1998) reported similar exposure-response curves at two time periods (2 years apart), after area-wide improvements had reduced exposure, indicating persistence of the excess response change effect.*"

5.35. In the longitudinal study at Schiphol airport, Breugelmans et al. (2007) reported no sustained adaptation in excess response to increased exposure over 2 ½ years after the change. There is thus no evidence from recent work to alter the conclusions reached by Horonjeff and Robert (1997), in their review of nine longitudinal studies, that there is "*little evidence that excess response attenuates within several years of the change*."

[43] Brown & Van Kemp, Estimating the magnitude of the change effect, 9th International Congress on Noise as a Public Health Problem (ICBEN) 2008, Foxwoods, CT

[44] Brown and Van Kamp: Response to change in noise exposure J. Acoust. Soc. Am., Vol. 125, No. 5, May 2009.

5.36. In the systematic review[45] for the WHO 2018 Guidelines Brown and Van Kemp comment regarding the life span of the excess response change effect that:

"*There is only a little evidence available with respect to long-term effects of the interventions. The studies generally undertook the after-outcome measures 2 to 12 months after the intervention, but two of them also repeated the after-measure, one 12 months after the first, the other 9 years after. The limited findings from these longitudinal studies are that this excess response undergoes some attenuation but is largely maintained out to several years.*".

5.37. Assessing the likely effects of noise from a proposed scheme solely in terms of the change in noise is the starting point and other factors should be also considered[46].

5.38. Studies demonstrate an excess response in situations of both increments and decrements of noise exposure: respondents whose noise exposure has increased report more annoyance than expected from steady-state studies; respondents whose noise exposure has decreased report less annoyance than expected from steady-state studies. The effect is present even for quite small changes in noise exposure.

5.39. In other words, human response to change in exposure may include a change effect as well as an exposure effect and the change effect manifests itself as an excess response in addition to the exposure effects that persists over time so that the number of persons reporting adverse effects after a change in noise is often greater than when comparing two different groups of persons subject concurrently to noise levels equivalent to the prior to and post change values.

5.40. The nature of the change influences the degree of change effect excess response, with abrupt Type 1 changes e.g. from a new or eliminated source, or change in intensity of the source (changes in aircraft or traffic flow rates, new road construction, additional or changed runway

[45] Brown & Van Kamp, WHO Environmental Noise Guidelines for the European Region: A Systematic Review of Transport Noise Interventions and Their Impacts on Health Kemp Int. J. Environ. Res. Public Health 2017, 14, 873
[46] IEMA Guidelines for Environmental Noise Assessment (2014)

configurations, for example) having a greater effect than Type 2 changes where there are no changes in the transport source flow rates or source noise emissions, just in exposure of the respondents (for example, the erection of barriers along roadways or railways or provision of noise insulation).

5.41. There are insufficient studies to reliably predict the duration of the change effect excess response. But the change effect excess response has been shown to be more than a short term effect and last for several years for changes in aircraft noise.

5.42. In the present case, neither the ES nor the AES acknowledge that an excess or change effect on enhancing the adverse impacts of aviation noise can occur.

5.43. In this case although there will be an increase in ATMs associated with the scheme it is unlikely to constitute a Type 1 step change. However, the likely increase in day time ATMs is likely to occur over a relatively short period of a number of years and the change in ATM numbers at night could happen much more quickly including from one year to the next. Consequently, it is considered that a change effect is likely, albeit the magnitude of the effect is likely to be less than for Type 1 circumstances.

6. THE ES AND AES

6.1. This section of this proof comments on the assessment work in the original Environmental Statement (ES) (CDs 2.5.16, 2.5.17 & 2.5.18) and Addendum Environmental Statement (AES) (CDs 2.20.1 and 2.20.4) to assess the likely significance of effect of noise impacts identified in the documents.

6.2. Paragraph 6.1.1. of the AES chapter 6 - Noise and Vibration; states that "*This chapter of the ES Addendum supplements Chapter 7: Noise and Vibration of the original ES (December 2018) and should be read in conjunction with this*." This section therefore includes comments in relation to both the original ES and he AES

Use of single LAeq,T metric is flawed

6.3. Both the ES and AES essentially assess the significance of the effects of the predicted noise impacts of the proposals using the LAeq,16 hr and LAeq, 8 hr for day and night respectively. The abbreviation LAeq,T is short hand for the Continuous Equivalent Noise Level (the A represents the A-weighting used to make the measurement more accurately represent how the ear responds to sound). The LAeq,T can be defined as the level of a hypothetical steady sound which contains the same sound energy as the actual variable sound, over a defined measurement period, T. By convention, the period t is from 0700 to 2300 hr for day and 2300 to 0700 for night.

6.4. However, aircraft noise is intermittent and typically each ATM results in peak noise levels above ambient and background levels; and even in quiet locations the background and ambient noise level from one moment to the next is rarely completely steady and in many circumstances will rise and fall substantially over short periods of time. This has led the science of acoustics to develop a range of noise metrics which aim to provide a more easily understood single figure representation of the sound environment in complex rapidly time varying situations.

Additionally, noise has a range of effects and different noise metrics can be best correlated to different specific effects, adding further to the number of metrics used to describe noise. Extra complexity comes in regard to aviation noise because different researchers have used varying indices when investigating the same aviation noise effect when trying to establish impact noise level values.

6.5. The ideal noise index for assessment of aviation noise would take account of at least the following attributes:

- The absolute or peak noise level of the over flight;
- The duration the noise of the over flight is audible at a location;
- The degree to which the over flight noise exceeds the ambient noise;
- How often the over flight noise occurs;
- Correlate well with the different impacts of the aviation noise e.g. annoyance, sleep and activity disturbance, speech interference etc.
- Be easily measured;
- Be capable of modelling/prediction;
- Be readily understood by non-specialists

6.6. Unfortunately, no single noise metric has yet been developed that can meet all the above requirements. Consequently, aircraft noise can be described in many different ways using various noise metrics, which can be classified into three types:

- Single event metrics: Measurements taken to describe the noise occurring during one aircraft over-flight e.g.

- Lmax, t – the maximum instantaneous noise level during the aircraft overflight period t
- N65 or 70 – the number of ATMs exceeding 65 or 70 decibels Lmax during the period T
- SEL – is the constant sound level that has the same amount of energy in one second as the original noise event which lasts for longer.

- Exposure metrics: Used to provide a description of the type of noise exposure experienced over a given period of time taking into account the number of overflights, the duration of each over flight and how loud each overflight is e.g. LAeq,T or Lden.
- Supplementary metrics: Measurements often used in conjunction with the above, to provide a more meaningful depiction of the potential impact of noise exposure e.g. Time above a stated threshold level, Person Exposure Index and Average Exposure index.

6.7. Although the LAeq,T noise metric is a convenient way of measuring noise as it aggregates how many noise events occur, how loud they are and how long they last for in a defined period it is relatively insensitive to changes in these factors. Consequently, because people hear aircraft noise disturbance as a discrete number of noisy events with associated noise levels, durations and noise characteristics, with breaks in between each ATM. Consequently, individual perception and the effects of noise are influenced by the intensity of each noisy event, the duration of that event and how often it occurs in the context of the background or ambient noise, the sensitivity of the activity an individual is engaged in and the duration of the breaks in between ATMs.

6.8. As I have explained above, this is reflected in the APF which at paragraph 3.19 states:

"Average noise exposure contours are a well established measure of annoyance and are important to show historic trends in total noise around airports. However, the Government

recognises that people do not experience noise in an averaged manner and that the value of the LAeq indicator does not necessarily reflect all aspects of the perception of aircraft noise. For this reason we recommend that average noise contours should not be the only measure used when airports seek to explain how locations under flight paths are affected by aircraft noise. Instead the Government encourages airport operators to use alternative measures which better reflect how aircraft noise is experienced in different localities,[96] developing these measures in consultation with their consultative committee and local communities. The objective should be to ensure a better understanding of noise impacts and to inform the development of targeted noise mitigation"

Foot Note 96 says – *"Examples include frequency and pattern of movements and highest noise levels which can be expected."*

6.9. Furthermore support for use supplementary noise indicators is found in the Air Navigation Guidance 2017 which at paragraph 311 and 3.12 directs the CAA to have regard to the following in regard to proposals for changes in use of airspace

"3.11 For communities further away from airports that will not be affected by noise above the LOAELs identified above, it is important that other aspects of noise are also taken into account where the total adverse effects of noise on people between different options are similar. Metrics that must be considered for these purposes include the overall number of overflights10 and number above metrics: N65 for daytime noise and N60 for night time noise.11 The CAA's overflights metric is a means of portraying those locations where residents will experience being overflown. These supplementary metrics must also be used to inform communities about the likely impact of proposed changes.

3.12 The CAA should also verify that sponsors have used any other noise metrics that may be appropriate for allowing communities to understand the noise impacts that could result from the proposed change. This could include the use of 100% mode contours for average noise or *frequency-based metrics, or consideration of the interaction with other sources of aircraft noise, such as those from other local airports"*

6.10. As well as average mode LAeq,t and Lden noise contours and data, the original ES included data, although little associated interpretive analysis, on the supplementary Number Above[47] metrics N70 (day), N60 (night), SEL and LAmax, and single[48] mode noise contours.

6.11. The AES provides average mode LAeq,t noise contours and data, Air Noise Difference Contours, LAeq,1h 06:00 - 07:00 and 6.5 hr 23:30 - 0600; and 90 dB SEL and LAmax contours.

6.12. Number above metrics are proposed for the Heathrow 3rd Runway ES along with LAeq,16 hr and 8 hr. For example, the Heathrow 3rd Runway Preliminary Environmental Information Report (PEIR) in PEIR Volume 1, Chapter 17 Noise and Vibration graphic 17.9 provides significance evaluation criteria for residential receptors for all noise sources. The process described is a relatively sophisticated two stage evaluation where following an initial evaluation against absolute noise levels designed to meet policy objectives in terms of Lowest Observed Adverse Effect (LOAEL) and Significant Observed Adverse Effect (SOAEL) there follows a second evaluation of multiple primary factors and then additional factors.

6.13. Graphic 17.9 in the PIER shows noise change as being a primary factor in identification of likely significant effects, along with noise level: day or night, evaluated using LAeq,16h and LAeq,8h metrics compared to the relevant LOAEL, SOAEL and UAEL values (refer to Table 17.14, PEIR Volume 1, Chapter 17 Noise and Vibration); and the population in the area that is exposed to the calculated noise change and noise exposure (see Table 17.17, PEIR Volume 1, Chapter 17 Noise and Vibration for population categories).

[47] Number Above metrics are the number of aircraft movements that will exceed a maximum noise level (LAmax) of the stated value within a defined period e.g. N60 and N70 are the number of aircraft that will exceed 60 dB LAmax or 70 dB LAmax during the night and day respectively.

[48] Average mode contours represent the average of the different directions aircraft approach and leave an airport (modes) over the 92 day summer period; whereas single mode contour represent the situation where all the aircraft on approach and leave an airport in a single direction.

6.14. The PEIR Volume 1, Chapter 17 Noise and Vibration categorises the evaluation of impact of changes in aircraft noise level as follows:

TABLE 1: NOISE CATEGORISATION FROM TABLE 17.17 LHR 3RD RUNWAY DCO PEIR

Noise change category Aircraft and ground noise dBA	Category
<1	Negligible
1 - 2 dB	Low
3 – 5	Medium
5 – 10 dB	High
6 – 9 dBA	Very High

Note d: Greater weight will be given to change in exposure, even slight changes on a small number of dwellings, if the area is already exposed to existing levels of noise that exceed the relevant SOAEL values to reflect the increasing risk of health effects at these levels of exposure.

6.15. At first sight the table above suffers from all the drawbacks of solely using change in the LAeq,t noise metric to assess noise impacts as described above.

6.16. However, graphic 17.9 of the PEIR Volume 1, Chapter 17 Noise and Vibration describes significance evaluation criteria for residential receptors for all noise sources based on a two phase based approach which includes an "additional factors" element in the second evaluation. These include a commitment to take into account "Additional metrics: e.g.

I. consider 100% mode LAeq metrics to better evaluate how adverse likely significant effects are reduced by predictable and valued respite through runway alternation; and,

II. use NAbove metrics to confirm adverse likely significant effects taking account of the noise level from each aircraft and number aircraft. For aircraft, additional metrics from ANG17, CAP1616 and Airports Commission[49]."

6.17. NAbove metrics are "Number Above - NA" indices, that are the total number of aircraft sound events that exceed a specified maximum sound level threshold (LAmax). Typical thresholds have been set at 60 dB at night[50], and 65 and 70 dBA during the day[51], with recent evidence[52] suggesting NA 65 dB has reasonable correlation with community annoyance response.

6.18. Appendix 17.1 Noise and Vibration in Annex D at paragraphs 2.2.13 and 2.2.14 pg 123 of the PEIR describes how the use of Number Above metrics will be used as part of the evaluation of significant noise effects, as follows:

"2.2.13 "The percentage change in N65, N60 and overflights in combination with absolute number will be calculated. Taking into consideration the Primary Factors and other Additional Factors, a likely significant effect would be avoided if the change in N65, N60 or overflights is low (less than 25%) and / or if the absolute value of N65 / N60 is low (N65 less than 20 or N60 less than 10). This will be a key consideration at the ES stage when considering likely significant effects that are identified on a precautionary basis at PEIR due to small noise increases at levels of noise exposure marginally above the relevant LOAEL.'

2.2.14 A moderate or high change in any of these additional metrics could be considered to confirm the likely significant effect identified using the primary factors (see Table 2.3). In such a case, a likely significant effect would be identified based on the three primary factors and an increase or decrease in the number of events."

[49] The Airports commission in their final report in 2015 used a matrix of LAeq, 16 and 8 hr, Lden and Number Above metrics to apprise the noise impacts of proposals to increase runway capacity in the South East of England.
[50] Approximately equivalent to the WHO Community Noise guideline of 45 dB LAmax inside a bedroom with windows partially open for ventilation
[51] Approximately equivalent to speech interference thresholds.
[52] CAP 1506/SONA 14 Survey of noise attitudes 2014: Aircraft

6.19. Appendix 17.1 Noise and Vibration in Annex D at Table 2.3 of the PIER provides a worked example of how the percentage change in N60, N65 and overflights will be used to evaluate significant noise effects, which is reproduced below along with.

TABLE 2: LHR PEIR APPENDIX 17.1 NOISE AND VIBRATION IN ANNEX D, **TABLE 2.3: CHANGE IN N60, N65 AND OVERFLIGHTS**

Category	**% change in metric (increase or decrease)** ***(LAeq,t equivalent, dBA)***	**Description**
Low	<24 *(<1 dBA)*	Likely significant effect avoided
Moderate[1]	25 – 49 (*1 to 2 dBA)*	Would contribute to identification of likely significant effect
High	>50 *(>2 dBA)*	Would contribute to identification of likely significant effect

Note 1: All else being equal, a 25% increase in number of movements would correspond to a 1dB increase in noise exposure.

6.20. Turning to the present case, paragraph 6.33 of the AES states that "*A number of supplementary indicators were also provided as part of the original ES.*". However, paragraph 6.3.5 says that "*The supplementary indicators in the original ES which have not been re-assessed still provide context as intended, although their precise values would likely change slightly due to the updated forecasts.*". The N70 and N60 contour showing the locations where the number of aircraft that will exceed these LAmax values during the day and night respectively have not been updated. Such information is important as it allows the effects of the development to be considered having regard for conditions as communities experience them. This is recommended by airspace policy e.g. the APF and Air Navigation Guidance 2017. The absence of update of the assessment of the supplementary noise indicators to reflect the changes because of the updated forecast and information on the noise characteristics of the modernised fleet of aircraft is considered a serious omission that substantially undermines the value of the AES as an aid to decision making in the knowledge of the full likely impacts of the scheme.

6.21. Assessing the likely effects of noise from a proposed scheme solely in terms of the change in noise is the starting point and other factors should be also considered.

6.22. Noise metrics represent a single figure representation of complex rapidly changing noise levels over a defied period. Small to moderate differences in the noise from individual aircraft movements may not be perceptible or can go unnoticed.

6.23. However, small changes in noise metric, especially cumulative energy based metrics such as LAeq,t, can represent substantial differences in the number of aircraft movements that are unlikely to go unnoticed.

6.24. The LAeq,t noise metric varies by a relatively small degree when substantial changes in the number and/or distribution of aircraft movements in the period t occur.

6.25. Smaller changes in noise can have a significant effect when a location is already subject to high noise levels, compared to less adversely affected areas.

6.26. Increases in noise probably have a stronger adverse effect than the beneficial effect of decreases in noise.

6.27. The nature of any noise change influences the degree of impact e.g. changes caused by introduction of a new noise source to a soundscape or increases in the number of noisy events are stronger than where the loudness of an existing noise source increases whilst the number of noise events stays the same.

6.28. As the policy documents and relevant research demonstrates, a full assessment of the impact of changes in noise for the BAL project has to go beyond simply considering the change in the LAeq,t noise metric. The failure to do this means that the Appellant has not present an appraisal of the impacts which captures all of the likely effects of the proposed development.

Assessment of additional awakenings at night

6.29. Paragraph 7B.6.45 of Appendix 7B to the ES comments that "*Research reported by Basner*[35] *recently for the WHO, records the findings of a more developed method of assessing sleep disturbance, stating that the gold standard for measuring sleep is polysomnography, which involves EEG but also eye movement and muscle tone measurement*." However, the ES does not go on to use the Basner method of predicting awakenings due to aircraft noise to assess sleep disturbance on the basis that Basner's "*research has not yet been translated into any direct guidance for the assessment of environmental noise at night*."

6.30. The AES is silent on the Basner method.

6.31. However, the Basner method was used to inform the assessment of awakenings at night in the ESs for the HS2 project phase 1 and 1a that have both been scrutinised and approved by House of Commons Select Committees and is proposed as part of the assessment of the sleep effects of noise from the 3rd Runway at Heathrow and HS2 phase 2b.

6.32. The omission of the assessment of additional awakenings due to aircraft noise at night is not in line with good practice and undermines the validity of the conclusions drawn in the ES regarding effects of noise at night on health and quality of life.

6.33. Additional awakenings are assessed using the LAs,max noise metric i.e. the maximum instantaneous noise level during an ATM, and the number of times at night i.e between 2300 and 0700 hrs an LAs,max noise event e.g an ATM, will ocurr.

6.34. The ES Appendices shows data in tables 7D.39, 7D.40 and 7D.40 regarding the N60 noise metric which represents the number of times at night an LAs,max of 60 decibels will be exceeded. These tables show that for 2026 the N60 contours for 12MPPA are predicted to cover a larger area, many more dwellings and therefore affect substantially more people than for 10 MPPA.

Metrics used for assessing sleep disturbance

6.35. The primary metric used in the ES and AES for assessing sleep disturbance is in terms of the percentage Highly Sleep Disturbed (%HSD) is the LAeq,t noise level over the 8 hours between 2300 and 0700 e.g. see ES paragraph 7.1.14 and AES Table 6.11. This represents the level of a constant sound over the night period that would contain the same overall noise energy as the actual varying noise level averaged over the same period.

6.36. However, the ES (at para 7.1.14) recognises that as well as considering the overall energy averaged noise level over the night period, the peak or maximum noise level from individual ATMs also needs to be considered. To do this the ES uses the LAmax noise metric, which the AES confirms is used at paragraph 6.3.3.

6.37. The ES at paragraph 7.1.17 states that the "*LAmax is commonly expressed in either "fast" or "slow" time weighting, denoted LAFmax and LASmax respectively. For aircraft noise, the convention is to use LASmax whereas for other noise sources, LAFmax is used.*". The slow time weighting was often used because in the early days of aircraft noise monitoring you had to visually estimate the level from a constantly moving needle on a dial, and fast time weighting made this difficult, slow time weighting reducing the speed and degree movement.

6.38. However, for quite some time now, fast time weighted metrics can be readily measured by modern SLMs.

6.39. The ES derives a criterion for using the LASmax metric in paragraph 7.9.27 where it states "*The WHO guidelines provide advice that for a good sleep, indoor sound pressure levels should not exceed approximately 45 dB LAmax more than 10-15 times per night. Accounting for sleeping with a bedroom window slightly open (and a reduction from outside to inside of 15 dB), this translates to an outside sound pressure level of 60 dB LAmax. (approx. 70 dB(A) SEL for aircraft noise*)." The Number Above metrics N60 for assessment of noise impacts at night is derived in this way.

6.40. However, the WHO Community Noise Guidelines 1999 in Table 1: Guideline values for community noise in specific environments are explicit in stating that the indoor guideline for bedrooms for noise from individual noise events of LAmax 45 dB is based on **fast** time weighting i.e. LAFmax in terms of the nomenclature used in the ES.

6.41. The use of slow or fast time weighting is important because slow time weighting will give a lower LAmax value of the same noise event e.g. aircraft fly over, as the equivalent LAmax value measured using fast time weighting.

6.42. The difference between LASmax and LAFmax measurement of the same aircraft movement can be between 1 to 6 decibels and is typically around 3 decibels[53].

6.43. This means that if the WHO LAFmax based night time guideline of 45 dB is to be assessed using LASmax data, then the threshold of effect should be reduced to at least 42 dB and as low as 39 dB. Once this is done, it substantially increases the catchment area the noise contour based on the LASmax metric used in the ES covers and captures residential properties that are not assessed in the ES as locations where adverse effect on sleep are likely.

6.44. Accordingly, the ES/AES approach of comparing LASmax forecasts with an LAFmax based guideline is inappropriate and understates the extent of the impact of the proposed development. An estimate of the area, number of dwellings and people that would be covered by using the fast time weighting to predict LAmax contours could be made by allowing a 15 decibel correction factor for the outside to inside noise levels difference of a bedroom with partially open window and using the 57 dB LAsmax noise contour as a proxy for a 60 dB LAfmax value equivalent to 45 dB LAfmax internal. Typically a 3 dBA difference in noise contour level is approximately equivalent to the 50% difference in the area covered i.e. a much greater area

[53] Aircraft Noise and London Heathrow Noise Monitoring Noise Monitoring Report Second Report Technical Report: st/07/20/NGGX037 March 2007

and therefore more people are likely to be exposed the ATMs giving rise to LAfmax noise events in bedrooms at night than suggested by the approach in taken for the ES and AES. .

Balance of the sharing of benefits of improved noise reduction

6.45. A fundamental element of the mitigation claimed in the ES and AES for the increase in ATMs that the rise to an annual passenger throughput to 12 million will cause, is that over time a greater proportion of the fleet mix using the airport will be less noisy than aircraft currently using the airport. In essence, it is claimed that whilst there will be more ATMs in future, a larger percentage of the increased movements will be aircraft not as noisy as currently or would be in future if the fleet mix did not change as assumed in the ES and AES.

6.46. The consequence of the airport trading off future relatively small reductions of a few decibels in the noise from individual aircraft, for increases in ATMs; is that this has a relatively modest effect in increasing the size of the cumulative averaged LAeq,t noise metric based contours.

6.47. However, this approach does not "share the benefits" of the future noise reduction of individual aircraft equitably[54]. This is because there is research[55] which shows that for different individual aircraft noise levels:

- A 2 to 3 dB difference between successive sounds was not particularly noticeable, although over half of the participants thought that it could lead to a more positive view of the airport, compared to providing no difference at all.

[54] E.g. Aviation Policy Framework 2013 - 3.12 "*The Government's overall policy on aviation noise is to limit and, where possible, reduce the number of people in the UK significantly affected by aircraft noise, as part of a policy of sharing benefits of noise reduction with industry.*" – repeated in para 3.1.3 of HMG's Aviation 2050: The future of UK aviation (2018); And para 5.6 of the ANPS "*The benefits of future technological improvements should be shared between the applicant and its local communities, hence helping to achieve a balance between growth and noise reduction.*"; and para 4.1 of DoTs Air Navigation Guidance: Guidance on airspace & noise management and environmental objectives "*The benefits of any future growth in aviation and/or technological development must be shared between those benefitting from a thriving aviation industry and those close to the airports that facilitate it.*"
[55] See https://www.heathrow.com/company/local-community/noise/making-heathrow-quieter/respite-research (Last viewed 6th June 2021)

- Differences of 5 to 6 dB between successive sounds may be needed for people to tell there is a difference.

- A difference of at least 7 or 8 decibels may be needed between the average sound level of two sequences of aircraft sounds to provide a valuable break from aircraft noise

6.48. In effect the airport is trying to off-set a noticeable increase in numbers of noisy ATMs against relatively small reductions in the noisiness of a hopefully increasing proportion of the aircraft over time. But this approach fails to recognise that each ATM will still be a noisy event that may either not be noticed as being less noisy or will not be "valued" by the local community as being quieter. This is the essential conundrum of trying to justify future increases in cumulative noise levels based on the total noise energy of all the noise events in a defined period, by arguing the extra noise events in future will be less noisy. There is a substantial likelihood that those affected will not detect or value the comparatively small reduction in the noise from each aircraft, but will notice the increase in still noisy flights.

Not all noise changes of the same magnitude have the same degree of impact

6.49. Again, regarding the equity of sharing the benefit of future aircraft. Table 7.21 Air noise impact ratings - change in noise level, outdoors and 7.22 Summary of magnitude of effect in the ES; and the equivalent AES tables 6.6 and 6.7. Imply that the magnitude of any effect due to a change in noise is the same if the change is an equal increase or decrease in noise.

6.50. In fact, there is evidence[2] that the effects of differences in individual aircraft noise are not the same if the difference is an equal increase or decrease in noise. The results of the study reveal that listeners are better (on average) at correctly identifying increases than decreases in the sound level of individual ATMs. The average discernible difference seems to be about +3 dB for increases, and around –6 dB for decreases i.e. twice the noise energy is required for a discernible decrease in aircraft noise compared to a discernible increase.

Magnitude of impact underestimated

6.51. ES Table 7.22 and AES Table 6.7 Summary of magnitude of effect – air noise, provides a matrix of outdoor noise levels linked to changes in noise categories associated with a semantic descriptor of the magnitude effect, so that as the change increases in size the semantic descriptor of effect becomes stronger. In addition, the degree of change linked to a semantic descriptor is reduced if the starting sound level before the change is above the adopted SOAEL value of 63 dB LAeq,16 hr assumed in the ES as effects occur with smaller changes at existing higher noise levels[56].

6.52. However, paragraphs 7.9.36 and 6.4.6 of the ES and AES state that a potential significant effect (adverse or beneficial) is considered to arise if the magnitude of the effect is rated as medium or higher as described in Table 7.22 of the ES or 6.7 of the AES . This requires a change of 3 to 6 decibels below a pre-change level of 63 dB LAeq,16 hr, and 2 to 4 decibels above 63 dB LAeq,16 hr.

6.53. It is important to note that the noise metrics the magnitude of effects described in table 7.9.36 of the ES and table 6.4.6 of the AES applies to are the LAeq,16 hr during the day and LAeq,8 hr at night. The LAeq,t noise metric provides a simplified single value to represent complex sound environments during which multiple noise events of variable duration and intensity and frequency content, can occur intermittently with periods of relative quiet in between e.g. in this case ATMs. Whilst on the one hand this provides a more easily conceptualised representation of convoluted circumstances, on the other hand the LAeq,t is rather insensitive

[56] As per the NPPG which says "*in cases where existing noise sensitive locations already experience high noise levels, a development that is expected to cause even a small increase in the overall noise level may result in a significant adverse effect occurring even though little to no change in behaviour would be likely to occur.*" Paragraph: 006 Reference ID: 30-006-20190722 Revision date: 22 07 2019

to increases in the number of noise events. For example, if you are measuring the noise of aircraft, and the total noise energy of 100 aircraft averaged out over a day as an Leq of 65 dBA; doubling the number of aircraft would only increase the LAeq,t by 3dB. You would have to raise the number of aircraft by tenfold to give the same increase in LAeq, t as a doubling of loudness (i.e. a 10 dBA increase) in the noise of individual aircraft.

6.54. The use of categories of change in the LAeq,t metric similar to those presented in the ES to assess the significance of changes in aviation noise has proven contentious at several airport planning inquiries; particularly where the time averaging period, t, is relatively longer e.g. 16 hours, than each individual noise event e.g. around 1 minute for each aircraft over flight.

6.55. Conventionally, the perception of changes in a noise level has been summarised as:

- A change in noise level of 1 dB is only perceptible under controlled conditions, and;
- A change in noise level of 3 dB(A) is the minimum perceptible under normal conditions.

6.56. In the past these conventions have been used to try and support the claim that changes in LAeq,t noise metric of less than 3 dBA can be rated as nil or negligible significance on the basis that such small changes are not perceptible or barely perceptible, as in the ES for this scheme.

6.57. In the present case, the ES seeks to set out air noise impact perceptibility ratings in terms of changes in noise level outdoors in table 7.21 of the ES and table 6.6 of the AES, which is reproduced below.

Table 6.6 Noise impact ratings - change in average noise level, outdoors

Change in noise level dB	Subjective impression	Potential Impact classification
0 to 2	Imperceptible change	Negligible
2 to 3	Barely perceptible change	Minor
3 to 6	Perceptible change	Moderate
6 to 9	Up to a halving or a doubling of loudness	Substantial
> 9	Equal to or more than a halving or doubling of loudness	Very substantial

6.58. However, at the Heathrow T5 Inquiry and other airport planning inquiries it was pointed out that crucial to the interpretation of the above convention in regard to the perception of changes in LAeq,t is an understanding of the differences between the terms noise level and noise metric. If the moment to moment noise level of steady sound, or the peak noise level of a specific noise event such as an ATM only changes by 3 dBA, then this is likely to be the minimum only just perceptible under normal conditions (as discussed in section 5.51 above[57]). Whereas, if the value of a noise metric, which is a simplified single figure means of representing a complex fluctuating pattern of noise over a much longer defined time period e.g. 16 or 8 hrs, changes by 3 dB or less, then the conventions described above may not be applicable.

6.59. For example, where the LAeq,t, changes by 3 dBA due to a doubling or halving of the number of noise events in the period t, then such a change in noise events is not likely to be imperceptible or barely perceptible; although the significance of any noticeable change will be influenced by factors including the number of noise events to begin with, the duration of the period t and the noise level of each noise event.

6.60. At public inquiries for various UK airport developments the claim that changes in LAeq,16 hr of 3 dB or less are not perceptible to barely perceptible has been challenged, and evidence presented that the subjective response to changes in aircraft LAeq,t noise levels containing a

[57] See footnote 2

series of discrete noise events with a large difference between the peak noise levels of the overflights and the minimum noise level of the periods between ATMs is more sensitive than claimed, particularly when the time averaging period is significantly longer than the duration of each noise event.

6.61. Typically, it has been pointed out that, as implied by tables 7D.3 of the ES Appendix D and Table 6.6 of a Addendum ES appendices, that a supposedly barely perceptible 3 dB reduction in noise level of each individual aircraft would permit a doubling of the number of aircraft movements, because the mathematics would mean there would be no change in the overall LAeq,t value and therefore no material increase in noise impact can be assumed. Consequently, as described in Table 7B.7 of the ES appendices, 2 to 3 decibel changes in LAeq, are imperceptible to barely perceptible, and the magnitude of effect of such changes is "very low" or "low", as described in Table 6.7 of the AES. Many find this counter intuitive as a doubling of the number of what are only at best marginally less noisy aircraft movements would tend to be clearly noticeable in a wide range of circumstances.

6.62. At the Heathrow T5 inquiry an expert witness for the DfT conceded that changes in LAeq,16 hr of less than 3 dBA could be significant. For example, if a less than 3 dB change in LAeq,16 hr was due to a large increase in aircraft movements overall or during a much shorter and sensitive part of that longer period e.g. early in the morning or late evening, being averaged over the longer 16 hour period. In which case even though the apparent variation in the LAeq,16 hr could be less than 3 dB, the impact of the increased number of noise events during the sensitive period would be likely to be clearly noticed by some of the persons affected.

6.63. The Civil Aviation Authority commented on this issue regarding the ES for the proposed extension of the runway at the George Best airport in Belfast as follows:

"*19. Furthermore, the Environmental Statement in discussing noise significance criteria claims that PPG 24 states that 'a change of 3 dB(A) is the minimum perceptible under normal* *conditions'. The Environmental Statement also presents a table (Table 4.7.2) describing the relationship between change in air noise level and subjective impression. The only statement in PPG 24 related to perceptibility is in the glossary. The text introducing the glossary explains that it contains explanations and the content of the glossary does not constitute a set of definitions. The issue of perceptibility is a frequent source of confusion. Statements of the type above claiming that changes of the order of 3 dB are the minimum perceptible under normal conditions relate to single noise events such as one aircraft flying over a particular location. The basis for such claims rests on experimental work conducted in laboratories during which human subjects are asked to differentiate between sounds of fixed frequency played to the subject at different noise levels. Single aircraft noise events are typically defined by either the Lmax (maximum sound level) or the Sound Exposure level (SEL) – the latter metric takes into account the duration of the aircraft noise event whereas the former simply takes the maximum or peak level recorded during the sound event. More details on noise measurement are available in the CAA's guidance (CAA, 2007 Appendix B Annex 2).*

20. Metrics employed for single aircraft noise events are different from those employed for the measurement of long term noise exposure of which the most common is Equivalent Continuous Sound Level abbreviated to Leq. A change of 3 dB in Leq can arise when the noise energy of all of the individual events doubles or the number of those noise events doubles or a combination of the noise energy of the events and the number of events increases. Thus, it is likely that a change of 3 dB will be of greater significance than that stated in the Environmental Statement.

21. Table 4.7.2 of the Environmental Statement does not feature in PPG 24 and its appropriateness in relation to Leq is questioned.

22. It is considered that the claims about the significance of noise criteria misrepresent the Government's planning policy guidance on noise. Noise exposure categories are inappropriate in considering new noise sources to be introduced into existing residential areas. Changes in *long term noise exposure are of greater significance than stated in the Environmental Statement."*

6.64. This issue featured in the planning appeal for the G1 proposals for Stansted airport to remove existing planning conditions which limited throughput to 25 million passengers per annum (mppa) to allow an increase to 35 million mppa. In paragraphs 14.100 to 14.106 of the report to the Secretary of State for the planning appeal for increased passenger capacity the Inspector considered the question of whether small changes in LAeq,16 hr due to substantial increases in ATMs would be perceptible. Concluding in his final paragraph on the subject that.

"*I consider that changes in the noise levels of individual aircraft noise events and the number of such events are important. I share the view of UDC that it is straining credulity to suggest that the noise from an additional 170 ATMs per day (on average, more in summer) would not be perceptible even though the Leq would increase by less than 1.5 dBA [5.59-65]*."

6.65. In paragraph 31 of his decision letter the Secretary of state confirmed he agreed with the Inspector's "*reasoning and conclusions on the living conditions and health of residents in the area, and the effects of aircraft noise on the quality of life of the area as set out in IR14.91-14.154*" i.e. including the extract from the IR quoted above.

6.66. Since levels of aircraft noise vary according to type, size, height and location of aircraft, the noise levels at a particular location differ. As a result, what matters is the extent to which people are annoyed or disturbed e.g. by interruptions to conversation or activities, and to assess this it is necessary to balance the loudness of the event against the number of times the events of different loudness occur.

6.67. The BAL proposal will increase the number of ATMs but will only result in small changes in the LAeq, 16 hr noise level; i.e. <3 dBA. The ES in Table 7.57 Summary of significance of adverse effects ranks the magnitude of these changes as "Negligible" and on that basis declares that the effect is "Not significant". But these small changes in LAeq,16 hr could be significant as they represent substantial increases in the number of times noisy ATMs events occur.

6.68. Table 6.1 in the AES shows the total number of Summer ATMs for day and night for each scenario assessed, and is reproduced as table 3 below, along with table 4 which shows the difference in numbers of ATMs between the 12MPPA and 10MPPA scenarios.

TABLE 3: TABLE 6.1 FROM THE AES SHOWING NUMBERS OF ATMS FOR DAY AND NIGHT OVER THE SUMMER PERIOD FOR DIFFERENT SCENARIOS

Scenario		Number of Aircraft Movements	
	Summer Daytime (07:00-23:00)	Summer Night-time (23:00-07:00)[1]	Annual Total
Original ES Scenarios			
Baseline 2017	18,924	2,735	73,562
10 mppa 2021 (Without Development)	19,294	4,022	86,973
12 mppa 2026 (With Development)	22,540	4,639	97,393
10 mppa 2026 (Without Development)	19,294	4,022	86,973
ES Addendum Scenarios			
10 mppa 2024 (Without Development)	20,882	3,330	76,310
12 mppa 2030 (With Development)	23,164	3,940	85,990
10 mppa 2030 (Without Development)	20,424	3,210	74,380

TABLE 4: INCREASES IN ATMS BETWEEN THE 10 MPPA AND 12MPPA SCENARIOS IN 2030

Scenario		Number of Aircraft Movements	
	Summer Daytime (07:00-23:00)	Summer Night-time (23:00-07:00)	Annual Total
Original ES Scenarios			
Baseline 2017	18,924	2,735	73,562
10 mppa 2021 (Without Development) increase over baseline	370	1,287	13,411
12 mppa 2026 (With Development) increase over 10MPPA 2021	3,246	617	10,420
12 mppa 2026 (Without Development) increase over 10MPPA 2026	3,246	617	10,420
ES Addendum Scenarios			
10 mppa 2024 (Without Development)	20,882	3,330	76,310
12 mppa 2030 (With Development) increase over 10 MPPA 2024 (without development)	2,282	610	9,680
12 mppa 2030 (With Development) increase over 10 mppa 2030 (Without Development)	2,740	730	11,610

Use of 55 dB LAeq,8 hrs as SOAEL at night is flawed

6.69. Tables 7.19 of the ES and table 6.3 in the AES show that a level of 55 dB LAeq,8 hr has been used to assess the policy threshold of SOAEL[58] at night.

6.70. There is precedent for such a value from Secretary of State decisions including the Heathrow Airport Cranford appeal.

6.71. However, airports where 55 dB LAeq,16 hr has been used to assess the policy threshold of SOAEL have mainly been in urban or suburban locations with relative higher ambient and background noise conditions, without taking aircraft noise into account, compared to the largely rural environs of Bristol airport.

6.72. Consequently, with a greater differential between underlying non-aircraft noise levels and aircraft noise levels around Bristol airport, aircraft noise is likely to be more intrusive than in urban locations where the higher non-aircraft ambient and background noise levels are likely to provide a greater degree of masking for a longer period of each ATM than in rural locations.

6.73. A recent ICCAN note reports[59] studies that show that:

- "*the effect of Lnight (i.e. LAeq,2300-0700) on %Highly Sleep Disturbed varied according to other factors (known as "effect modification"). the intermittency ratio (IR) to measure the intermittency or "eventfulness" of noise, that is how much loud events stand out from the background noise levels. First, they used the intermittency ratio (IR) to measure the intermittency or "eventfulness" of noise, that is how much loud events stand out from the background noise levels. A high IR means the loud event interrupts otherwise quieter*

[58] See Noise policy Statement for England (NPSE) Para 2.21 "*SOAEL – Significant Observed Adverse Effect Level This is the level above which significant adverse effects on health and quality of life occur*"
[59] Aviation noise and public health rapid evidence assessment, ICCCAN July 2020.

background noise, while a low IR means the background noise is higher. The study found that with levels of L night up to around 50 dB, participants with low IR (higher background noise) reported significantly lower levels of %HSD. They also found an effect modification in degree of urbanisation, whereby for a given level of L night, %HSD is highest in rural areas,

- A study that "*found a significant association between Lnight and sleep disturbance, with 15% higher odds for being highly sleep disturbed for each 1 dB increase in Lnight*."

6.74. The ES's use of 55 dB LAeq,8 hrs as SOAEL is drawn from the WHO Night Noise Guidelines (NNGs), which in section 1.3.6 states "*Most levels mentioned in this report do not take background levels into account*". Indicating that the NNGs do not allow for increased %HSD due to intermittent noise events in low noise locations.

6.75. Furthermore, the WHO Guidelines for Community Noise comments in regard to sleep disturbance in the executive summary that "*Special attention should also be given to: noise sources in an environment with low background sound levels*;".

6.76. Paragraph 6.3.1 of the AES states that "*The scope of this assessment is restricted to changes as a result of the updated forecast and information on the noise characteristics of the modernised fleet of aircraft, and the provision of additional explanatory information relating to the night period. The key aspects of the scope are summarised in this section and reference should otherwise be made to Chapter 7 of the original ES*."

6.77. In regard to night time noise impacts Table 6.9 Air noise dwelling counts, LAeq,8h average mode summer night shows that in 2030 the scheme is predicted to substantially increase the number of dwellings exposed to the LOAEL and SOAEL noise thresholds from the AES of 45 and 55 decibels respectively compared to a no scheme scenario. If the LOAEL threshold of 40 dB Lnight from the WHO Night Noise Guidelines for Europe 2009 is used the number of dwellings exposed will be substantially greater than the 4000 reported in this table. The WHO

NNG LOAEL of 40 dB Lnight is regarded as more appropriate in the largely rural locations around the airport affected by aircraft noise at night as these locations have lower background and ambient noise conditions, which as previously described means the aircraft noise has a greater impact.

6.78. For night-time noise, the use of 'awakenings' to describe effects is considered useful as this allows sleep disturbance to be considered in terms of increased risk. For example, a small increase in night-time LAeq caused by a modest increase in the number of ATMs can be equated to a corresponding percentage change in the risk of objective awakenings allowing the effects to be described. This metric has been recently used or committed for use for assessment purposes at Manston Airport, Leeds Bradford Airport and the Heathrow Airport 3rd runway. Unfortunately, the AES continues to follow the ES in not considering additional awakenings.

6.79. Table 6.5 of the ES and the equivalent table 7.2 in the AES describe Noise impact assessment criteria (absolute) – non-residential, outdoors and confirms that the LAeq,16hr noise level is the only metric used for assessing impacts on schools and children cognitive development. The LAmax metric is considered helpful to understanding the effects on schools and children cognitive development and consideration of the potential impacts on schools having regard to changes in noise exposure (Leq) and event metrics (e.g. Nx) over the school day would have helped further articulate these effects and provide wider consideration of the effects of the development against the BB93[60] guidelines which assess individual noise impacts using the L1 metric. Such analysis considering noise exposure over a school day is also absent from the AES. Based on the data presented in Table 6A.46 of the AES appendices on the LAeq,16 hr noise metric the 12 MPPA scenario has an apparently modest effect in increasing the LAeq,16 hr noise metric by 1 decibel, albeit the starting point at 10 MPPA is already above the BB93

[60] BB93: acoustic design of schools - performance standards Building Bulletin 93 (BB93) explains minimum performance standards for the acoustics of school buildings. The guidance says that "*in order to protect students against regular discrete noise events e.g. aircraft or trains ambient noise levels should not exceed 60 dB LA1,30 min.*" The LA1 noise metric is the noise level exceeded for 1 percent of the defined time period and is difficult to predict for aircraft movements, in which case the LAmax can act as a proxy.

guidelines of 55 dB LAeq, 30 mins for at least 1 school (Winford Primary, Winford). The event noise metrics were not updated in the AES but the data in Tables 7D.36, Table 7D.37 and Table 7D.38 of the appendices to the original ES show the area, number of dwellings and population counts for the number of times an LAmax of 70 dBA would be likely to be exceeded 10, 20, 50, and 100 times a day increases with the 12MPPA scheme compared to the 10 MPPA scheme in 2026. This trend indicates a worsening of the already significantly adverse effect of aircraft noise on the acoustic conditions at the school.

Failure to consider and apply the WHO Environmental Noise Guidelines 2018 (ENG18)

6.80. Although the ES in Table 7.3 - Technical guidance relevant to noise and vibration and in Appendix 7B at paragraphs 7B.5.11 and in the AES at paragraphs 6.2.8 to 6.8.11 acknowledges the WHO Environmental Noise Guidelines for the European Region (ENG18). These sections of the ES make it clear the ENG18 have been considered only in relation to sleep disturbance.

6.81. The ENG18 considers a range of noise effects including direct health effects such as cardiac effects, impacts on children's' cognitive development and annoyance. However, the ES does not seem to have used the ENG 18 advice regarding any of these effects.

6.82. The ENG18 recommendations in relation to aircraft noise annoyance have proven contentious as they suggest a radical increase in the proportion of a population exposed to aircraft noise who are Highly Annoyed (HA) compared to earlier studies; and recommends reducing aircraft noise to levels that could only be achieved by drastically curtailing the number and types of aircraft using an airport, based on controlling annoyance and thereby avoiding other health and quality of life effects that start to occur at levels higher than the onset of annoyance. Notwithstanding these recommendations ignore the associated economic and social costs of compliance; the ENG18 do provide dose responses that can be used to assess health and quality of life effects other than annoyance and as sensitivity tests for annoyance.

6.83. The UK SONA14/CAP 1506 study (referenced in the ES and AES) also found increased sensitivity to aircraft noise compared to the previous UK ANIS study from the 1980's that underpinned UK aviation noise policy, albeit not to the same extend as the ENG18. For example the SONA14 study found that nowadays the proportion of the population likely to be highly annoyed by aircraft noise at the previous benchmark for onset of significant community annoyance of 57 decibels LAeq,16, now occurs at 54 dB LAeq,16 hrs compared to the previous study in the 1980's. Although the trend for greater sensitivity to aircraft noise halted at 63 dB LAeq,16 hrs and community sensitivity reduced above this value.

6.84. The ENG18 is clear about its limitations and states that where local dose responses have been established e.g. UK SONA14/CAP 1506, the WHO guidance advises that these should continue to be used.

6.85. Notwithstanding the ENG18 limitations, as I have explained above the ICCAN have recently highlighted shortcomings in the UK SONA14/CAP 1506, particularly regarding assessment of changes in noise conditions.

6.86. Consequently, in my view the ENG18 have a role in assessing aircraft noise in the UK as a sensitivity test providing an additional understanding of the effects of the development should alternative dose-response relationships be applied, as is proposed for the Heathrow 3rd runway ES in the Preliminary Environmental Information Report at paragraph 1.13 of Appendix 17.1, Annex E.

6.87. At paragraphs 6.2.10 the AES seeks to justify rejecting the WHO Night Noise Guideline Level of 40 dB Lnight as part of the assessment and using a value of 45 dB Lnight instead. The reasoning is that to do so would impose "*very significant restrictions on the current permitted operations of most major airports*". This is true, if it were to be applied as a blanket hard immutable threshold which can not be breached at any cost. However, in EIA terms that is a weak reason to not use a relevant guideline for assessment of effects. Instead the guideline, albeit it is not favourable to a noisy industry, should be applied and the associated adverse and significant adverse effects evaluated and then avoided were possible in the context of Government policy on sustainable development, the adverse effects mitigated; and the residual impacts weighed against the social and economic benefits of the noise generating scheme. Rather than avoiding using a relevant benchmark of effect because it might be unfavourable to a scheme.

6.88. The level of 40 dB Lnight is the threshold for the policy objective LOAEL used in the ES for HS2 phase 1 and 2a as approved by parliament, and in the ES for phase 2B of the HS2 scheme. Given the parliamentary recognition of this guideline and the broadly rural nature of the location of the airport with low background and ambient noise levels, in my view the lower WHO NNG threshold of 40 dB Lnight represents LOAEL for the proposed development.

6.89. As a result, the impact of the proposed development assessed using at night of 40 dBA Lnight LOAEL instead of 45 dBA will be to substantially extend the area and therefore increase the number of dwellings and people exposed to noise levels above which adverse effects would be likely and which policy states the effects of which should be mitigated and minimised.

Assumed aircraft noise performance

6.90. The forecasts for both the without and with development scenarios in the ES make assumptions as to the fleet mix and, importantly, the number of latest generation aircraft types which are less noisy than those using the airport currently, using the airport in each assessment year. Notwithstanding any general concerns as to the robustness of the demand forecast in the context of aircraft noise, paragraph 7.7.2 of the ES states that Airbus A320neo and A321neo, and also the Boeing B738MAX aircraft types are included in the assessment. These aircraft are acknowledged be less noisy than the latest noise requirements agreed international standards i.e. ICAO Chapter 14.

6.91. At the time the ES was published the Boeing 738max, A320neo and A321neo aircraft had only recently entered service. However, Tables 7D.9, Table 7D.10, Table 7D.11 and Table 7D.12 in appendix 7D indicate that the noise data for the A320neo and A321neo aircraft used to model the airport noise emissions was validated, but the data for the Boeing 738max was not validated.

6.92. Consequently, whilst the noise modelling underpinning the future noise emissions from aircraft using the airport of the ES for the Airbus aircraft types is based on validated aircraft noise performance, the data for the Boeing 738 max aircraft is that within the AEDT[61] noise model data base derived from the noise certification data available for this type[62].

6.93. The way aircraft noise is certified can not necessarily represent how it will generate noise when in use by a particular airline at a specific airport. It therefore follows that the noise performance of this aircraft at Bristol airport may not be as assumed in the AEDT. The ES takes this into account to a degree by using data from the Noise Monitoring Terminals to establish correction factors for (see AES Table 6A.10 Average measured and default predicted noise levels and validated modifications for details). These corrections are only reported for the Airbus aircraft and not for the Boeing 737 MAX 8 aircraft type (see AES appendices - Updated Aircraft Information, 9th page)

6.94. Unfortunately, the ES does not consider a scenario where the noise performance of the Boeing 737 MAX 8 aircraft type at Bristol airport is not as indicated by the AEDT designation, as was found for the A320neo and A321neo aircraft as shown in Table 6A.10 Average measured and default predicted noise levels and validated modifications in the AES appendices. A robust assessment taking into account the uncertainty regarding the noise data for the Boeing738max

[61] Aviation Environmental Design Tool (AEDT) is a software system that dynamically models aircraft performance in space and time to produce fuel burn, emissions, and noise.

[62] Aircraft have to meet specified noise performance limits to qualify for various noise chapters defined by the ICAO. This involves a standardised method of measuring noise on arrivals, departures and lateral to the runway. This provides a reasonable means of comparing how noisy different aircraft types or variants of the same aircraft are, but does not necessarily reflect how noisy a plane will be when flown at a specific airport or by a particular airline/pilot with different engine and flight control settings to those required by the standardised ICAO noise test.

aircraft would have been for this aircraft type not to have been used in models of future scenarios and instead an appropriately validated aircraft substituted thereby providing a bench mark of the potential maximum noise emissions unlikely to be exceeded. This would most likely mean that the area and therefore number of sensitive receptors covered by the noise contours and therefore subject to adverse and significantly adverse noise effects would increase, albeit probably by a modest degree.

Assumed fleet mix

6.95. Tables 7D.9, Table 7D.10, Table 7D.11 and Table 7D.12 in appendix 7D show the assumed fleet mix for each of the with and without development scenarios where airport noise emissions have been modelled.

6.96. These tables show that from the baseline of 2017 to the future 2026 scenario the proportion of the less noisy Boeing 738max, A320neo and A321neo aircraft is assumed to grow until they represent a substantial majority of ATMs at the airport. This growth in less noisy aircraft using the airport in future is critical to limiting the predicted modest future increase in size of the modelled noise contours to that used in the ES, given the considerable increase in ATMs required to facilitate the airports aim to grow passenger movements to 12 million in 2026.

6.97. Jacobs have reviewed the likely future fleet mix and produced a different predicted fleet mix (Addendum Review - Busy Day Flight Schedule and Fleet Mix Review, (CD10.38) which shows that the rate of introduction of less noisy more modern aircraft e.g. Airbus 320neo, Airbus 321neo and Boeing 737 8 max is unlikely to be as fast as York Aviation (YAL) have advised BAL, with a greater proportion of the older noisier Boeing 737-800 aircraft staying in the fleet mix for longer now that Jet 2 are based at the airport. The table below reproduces figure 3 from the Jacobs review showing a comparison between the YAL and Jacobs predicted future fleet mixes.

TABLE 5: COMPARISON OF THE YAL AND JACOBS PREDICTED FUTURE FLEET MIX (JACOBS REVIEW FIGURE 3)

Aircraft	YAL 2030 Fleet Mix	Jacobs 2030 Fleet Mix distribution	Jacobs 2030Fleet Mix	Variation between Jacobs & YAL
Boeing 737-800 (winglets) Passenger	2,380	18%	13,781	11,401
Airbus A320neo	20,200	33%	24,538	4,338
Airbus A321neo	15,720	13%	9,887	(-5,833)
Boeing 737 MAX 10	2,050	3%	2,097	47
Boeing 737 MAX 8	14,360	16%	11,684	(-2,676)
Airbus A319	-	-	-	-
Airbus A320	6,540	4%	2,828	(-3,712)
Airbus A321	-	-	-	-
ATR 72	8,360	7%	5,225	(-3,135)
Boeing 737 Passenger	-	-	-	-
Boeing 737-700 (winglets) Passenger	750	3%	2,397	1,647
Boeing 737-800 Passenger	-	-	-	-
Boeing 757-200 (winglets) Passenger	-	-	-	-
Boeing 767-400	-	0.4%	300	300
Boeing 777	-	0.4%	300	300
Boeing 787-8	510	0.8%	599	89
Canadair Regional Jet 900	-	-	-	-
Embraer 175	-	-	-	-
Embraer 190	2,240	0.8%	599	(-1,641)
Embraer 195-E2	2,240	-	-	(-2,240)
Embraer RJ145	-	1%	1,115	1,115
	75,350	**100%**	**75,350**	**-**

6.98. The Jacobs analysis in the table above shows that in future there is likely to be retention of a considerable proportion of Boeing 737-800 aircraft and a lower proportion of Airbus 320neo, Airbus 321neo and Boeing 737 max aircraft in the fleet mix; compared to the YAL analysis. This pattern of development of the fleet mix has potential to influence the prediction of future noise as the Boeing 737-800 aircraft is noisier than the Airbus 320neo, Airbus 321neo and Boeing 737 max aircraft that YAL predict will largely replace it by 2030.

6.99. The data from Tables 7D.16 and 7D.17 of the original ES and Table 6A.10 of the AES shows the typical SEL noise levels of several of the aircraft types that will dominate the noise produced at the airport, measured at noise Monitoring Terminals 2 and 5 (NMTs) around the airport. This data can be combined with the fleet mix information in Table 5 above to estimate the contribution of individual aircraft types to the overall 24 hr LAeq,t noise level based on an average of the SELs at NMTs 2 and 5 for both the YAL and Jacobs fleet mixes; and assuming each ATMs has a duration of, say, 15 seconds, to indicate the potential difference in noise between the two fleet mixes at a notional location, as show in the table below:

TABLE 6: Calculation of the difference in LAeq,T between the YAL and Jacobs fleet mixes at a notional location

	YAL		**Jacobs**		**Difference between YAL and Jacobs fleet mixes**	
Aircraft	**Departures LAeq,T dB**	**Arrivals LAeq,T dB**	**Departures LAeq,T dB**	**Arrivals LAeq,T dB**	**Departures LAeq,T dB**	**Arrivals LAeq,T dB**
Boeing 737-800 (winglets) Passenger	56.4	56.0	64.1	63.7	7.6	7.6
Airbus A320neo	60.6	63.4	61.5	64.3	0.8	0.8
Airbus A321neo	61.2	63.4	59.2	61.4	-2.0	-2.0
Airbus A320	58.2	59.6	54.6	56.0	-3.6	-3.6
				Total	3.6	3.6

6.100. The above analysis is for a notional location and is not as precise as if the full noise modelling in the ES and AES was repeated with the Jacobs fleet mix as it does not include all the aircraft and the assumptions regarding flight paths and modelling used with the AEDT software to generate the noise predictions for the ES and AES. But it does show that because the Jacobs future fleet mix retains a greater proportion of the noisier Boeing 737-800 aircraft and a smaller proportion of the Airbus 320neo, Airbus 321neo and Boeing 737 max aircraft for the same overall number of aircraft as the YAL fleet mix. The overall predicted LAeq,t noise levels could be around 3 dBA higher. In which case, the noise contours would be approximately 50% bigger and more noise sensitive locations and a greater number of people would be likely to be adversely and significantly adversely effected than presented in the ES and AES.

6.101. However, the ES and AES only reports assessment of one fleet mix.

6.102. The noise chapter of the ES neither provides evidence nor references any other sources that shows the assessed assumed future fleet mix can be guaranteed.

6.103. The degree and rate at which airlines will acquire newer less nosy aircraft is subject to a range of national and international commercial, political, and environmental risks that could slow the rate at which less noisy aircraft enter the fleet mix. The ES should therefore have included assessments of variations around the assumed fleet mix with the proportion of less noisy aircraft growing at different rates to those assumed in the ES so that the effects of the risk that the change could be slower than anticipated could be evaluated.

6.104. The AES at paragraph 6.1.2 confirms that "*In addition to the Core Case, a sensitivity test has been undertaken on a qualitative basis to a Faster Growth Case (2027) and a Slower Growth Case (2034)*.". Paragraph 6.3.13 goes on to say "*A sensitivity test on a qualitative basis has also been carried out for Faster and Slower Growth Cases of 12 mppa in 2027 and 2034, respectively*."

6.105. Paragraphs 6.7.16 to 6.7.21 of the AES discuss the sensitivity tests and conclude that although noise levels could be 0.5dB A higher and contours 10% larger, a qualitative assessment leads to the conclusion that there will be no significant adverse effects.

6.106. A qualitative assessment is not considered adequate in this case. Appraisal of the effects of the scheme is dependent on the assumed fleet mix and the resulting noise levels and magnitude of the noise contours and the distribution and number of noise sensitive properties and the persons within them. The uncertainty around the proportion of less noisy aircraft to noisier aircraft in the fleet mix and the rate at which the number of passengers changes are not interdependent and any sensitivity test should include disaggregating these factors e.g. a faster passenger growth rate with no or slower increase in the proportion of less noisy aircraft would lead to higher noise levels and larger noise contours affecting more people.

6.107. Paragraph 6.2.7 of the AES states that "*It is of note that BAL currently, and as part of the application, proposes to control noise emissions in full compliance with 2) above, operating a noise contour area limit to control daytime noise and a QC limit (alongside additional aircraft movement restrictions) to control night noise. Any regular reporting requirements that were to arise under items 3) and 4) would be included in Bristol Airport's Annual Monitoring Report*. " As discussed below, the changes assumed in the AES in fleet mix and the rate of introduction of less noisy aircraft are critical to keeping noise impacts to those described in the AES, but are subject to uncertainty. This leads to legitimate concerns that the noise effects can become worse than those at presented. Consequently, noise contour restrictions need to be based on appropriate values relating to effects with ongoing review and reporting against up to date policy as it evolves.

6.108. Concerns regarding the uncertainty of future noise predictions are further justified by evidence from various sources including a recent CAA report[63] which found noise from aircraft in normal operation at an airport can be different from that the declared certified noise levels:

"*Arriving aircraft rarely land at maximum weight and often land with reduced landing flap selected. Consequently, arrivals noise measured at the approach reference point may be expected to be lower than in certification. However, the operational approach levels of 13 aircraft types (out of 111) lie entirely above their QC bands. These include variants of the B757-200, B757-300 and B767-300, a finding consistent with measurements published previously in ERCD Report 0205. These differences cannot be explained in operational terms.*

[63] CAP 1869 Quota Count validation study at Heathrow Airport 2020

On departure, the operational levels of 21 aircraft types (out of 131) lie entirely above their QC bands, including variants of the A320neo and B737 MAX 8. Operational differences between normal airline service and certification mean that departure noise is distributed differently along and about the flight path.

Generally, measured in-service lateral levels are expected to be lower than in certification. This is because aircraft rarely fly at maximum weight and typically use a reduced engine power setting on take-off to save fuel and minimise engine wear."

6.109. The CAA report highlights that operational noise can by higher than the levels aircraft are certified at, including for two aircraft types i.e. A321neo and the B737 Max 8 which are expected to use Bristol airport and are critical to the future noise predictions presented in the ES.

6.110. The AES now presented validated data for the A321neo aircraft and the noise predictions now allow for any difference between the Certified noise levels that inform the AEDT database used to derive the noise contours presented.

6.111. However, AES noise contours use the AEDT database for noise information about the B737 Max 8 aircraft type which has not been validated against measurements using the NMTs at Bristol airport. Consequently, there is a risk that the contribution of this aircraft type to future noise predictions for the airport has been underestimated.

7. AIR NOISE IMPACTS OF THE PROPOSALS

7.1. In this section the noise impacts mainly from aircraft in flight as presented in the AES are considered.

Day time impacts

7.2. Table 6.8 Air noise dwelling counts, shows that in 2030 with the scheme in place an additional 500 dwellings are predicted to be above a LOAEL based on a LAeq,16h average mode summer day value of 51 dB, compared to the same year but without the scheme in place.

7.3. Regarding a SOAEL based on a LAeq,16h average mode summer day value of 63 dB the same number of dwellings are predicted to be exposed at or above this level in 2030 without the scheme.

7.4. Table 6.10 Highly annoyed population count, LAeq,16h average mode summer day shows that in 2030 an additional 100 persons are predicted to be highly annoyed by aircraft noise compared to the same year but without the scheme.

7.5. Table 6.13 Air noise exposure levels at representative residential locations, LAeq,16h summer day shows that the difference in predicted LAeq,16h summer day noise levels in 2030 with and without the scheme is between 0 and 1 dB (after rounding).

7.6. However, no evaluation of the N70 values is provided in the AES meaning the critical information on how often this threshold for onset of impacts is expected to be exceeded is .

Night time impacts

7.7. Table 6.9 Air noise dwelling counts, LAeq,8h average mode summer night shows that in 2030 with the scheme in place an additional 600 dwellings are predicted to be above a LOAEL based on a LAeq,16h average mode summer night value of 45 dB, compared to the same year but without the scheme in place.

7.8. Regarding a SOAEL based on a LAeq,8h average mode summer night value of 55 dB, 150 more dwellings are predicted to be exposed at or above this level in 2030 with the scheme in place compared to without the scheme. That an additional 150 households exposed to noise above a level which national noise policy should be avoided. In total with the proposed development in place the airport will expose these additional households to noise levels at night which are to be avoided. These factors indicate that the proposed development is contrary to national noise policy on this basis alone and points to refusal of planning permission.

7.9. Table 6.11 Highly sleep disturbed population count, Lnight average mode annual night shows that 100 more people are predicted to be highly sleep disturbed in 2030 with the scheme in place compared to without.

7.10. Table 6.12 Air noise dwelling counts, individual events, average summer night shows that the number of dwellings exposed to SEL and LAmax levels above 90 dBA and 80 dB respectively at least once a night are the same in 2030 with or without the scheme. But this would be expected as it would only take one of the ATMs to be the same most noisy aircraft at night for this to occur. Because the likelihood of additional awakenings has not been assessed as per the Basner method the adverse effect of the number of noise events at a particular LAmax level on sleep has not been appropriately assessed.

7.11. The SEL and LAmax levels above 90 dBA and 80 dB respectively presented as SOAEL in the ES and AES are thresholds designed to reflect the probability of behavioural/awakenings. Simply basing the assessment criteria on recalled awakenings will effectively neglect the adverse effects of noise resulting from:

- fragmentation of the sleep cycle and interference with sleep quality caused by noise induced EEG/physiological awakenings at event noise levels below which recalled awakenings will occur; and,
- impairment to the process of falling asleep again.

7.12. From a public health perspective, such effects should not be ignored when they occur frequently, as is likely regarding the populations exposed to noise at night from ATMs to and from Bristol airport.

7.13. Table 6.14 Air noise exposure levels at representative residential locations, LAeq,8h summer night shows that the difference in predicted LAeq,8h summer night noise levels in 2030 with and without the scheme is between 0 and 1 dB (after rounding). But no evaluation of the N60 values is provided in the AES meaning the critical information on how often the threshold for onset of impacts on sleep due to the maximum noise from individual ATMs is expected to be exceeded is available. This is important as small changes the 8 hour long Lnight can reflect substantial and sleep critical differences in the number of noise events. This point is illustrated well by Basner[64], as follows:

"Reducing the number of ANEs [Aircraft Noise Events] by 50% without changing the aircraft types means that the energy equivalent continuous sound level LAeq will decrease by 3 dB. Criteria solely depending on LAeq therefore implicitly assume that the effects of aircraft noise on sleep are simultaneously diminished by 50%, e.g., that the number of awakenings induced by aircraft noise is halved. Figure 4 demonstrates that this is not true. Following the epidemiologic concept of numbers needed to harm, it shows, depending on the maximum SPL of single ANEs, how many ANEs are needed to induce one additional awakening on average, where independent events were assumed. If the maximum SPL of single ANEs is reduced by 3 dB from 72 to 69 dB, the permitted number of ANEs inducing one additional awakening may

[64] J. Acoust. Soc. Am., Vol. 119, No. 5, May 2006 Basner et al.: Aircraft noise effects on sleep

not be doubled but only increased by 11% from 10.6 to 11.8 movements. The allowable change in the number of ANEs following reductions in maximum SPL of 3 dB increases continuously from 11% decrease (from 72 to 69 dB) to 97% decrease (from 39 to 36 dB), i.e, the number of ANEs may be nearly doubled only very close to the threshold value of 33 dB."

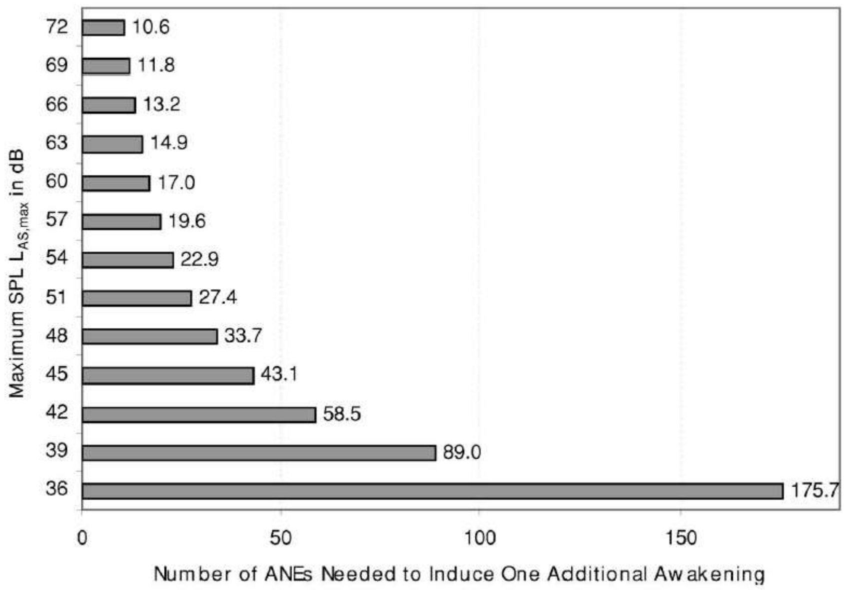


FIG. 4. Number of ANEs needed to induce one additional awakening on average and depending on the maximum SPL. Results are based on the dose-response relationship found in the field study (see Table I).

7.14. Basner's approach to assessing additional awakenings has more recently been further refined[65]. Basner et al's latest algorithm for calculating the likelihood of a typical person moving to sleep stage 1 (light sleep) or awake (behavioural/recalled awakening), is as follows:

$$\text{Probability of Wake or S1} = -3.0918 - 0.0449 - LA_{S,max} + 0.0034 - (LA_{S,mx})^2$$

7.15. The table below uses the above algorithm to show the % chance of changing to wake or Sleep stage 1 and the number of ATMs to induce an additional recalled awakening from an LAs,max nise level inside a bedroom ranging from 40 - 65 dB(A). These values are equivalent to 55 to 80 dBA externally (the AES uses an external SOAEL of 80 dB LAMax).

[65] E,g, M. Basner and S. McGuire. (2018) WHO Environmental Noise Guidelines for the European Region: A Systematic Review on Environmental Noise and Effects on Sleep. International Journal of Environmental Research and Public Health.

TABLE 7: THE % PROBABILITY OF AN AVERAGE INDIVIDUAL CHANGING TO WAKE OR SLEEP STAGE 1 AND THE NUMBER OF ATMS TO INDUCE AN ADDITIONAL RECALLED AWAKENING WITH REFERENCE TO LAS,MAX

LAs,max dBA in bedroom	Probability of waking (%)	No of ATMs for an additional awakening
40	0.6	181
41	0.8	128
42	1	98
43	1.3	79
44	1.5	66
45	1.8	56
46	2	49
47	2.3	43
48	2.6	39
49	2.9	35
50	3.2	32
51	3.5	29
52	3.8	27
53	4.1	25
54	4.4	23
55	4.7	21
56	5.1	20
57	5.4	19
58	5.7	17
59	6.1	16
60	6.5	15
61	6.8	15
62	7.2	14
63	7.6	13
64	8	13
65	8.4	12

7.16. Table 6.18 in the AES shows that at night in 2030 with 10MPPA there are predicted to be 20 arrivals and 15 departures and with 12MPPA there are predicted to be 23 arrivals and 19 departures i.e. the scheme means more ATMs at night.

7.17. The table above show that with number of nigh time ATMs in the 10MPPA scenario additional awakenings would arise on departures at 56 dB LAs,max in bedrooms and on arrivals at 60 dB LAs,max, equivalent to 71 dB and 75 dB LAs,max externally[66] i.e below the SOAEL of 80 dB LAs,max in the AES. These levels would arise further from the airport than the area covered by the current noise insulation scheme.

7.18. The table above also shows that with the number of night time ATMs in the 12MPPA scenario additional awakenings would arise on departures at 54 dB LAs,max in bedrooms and on arrivals at 57 dB LAs, max, equivalent to 69 dB and 73 dB LAs,max externally i.e further below below the SOAEL of 80 dB LAs,max in the AES. These levels would arise at a greater distance from the airport than the area covered by the proposed noise insulation scheme and over a wider area and therefore affect more people than for the 10 MPPA scenario i.e. in 2030 a greater number of persons would be likely to experience an additional awakening at night with the 12MPPA scenario compared to 10MPPA.

7.19. The table below shows the calculated additional awakenings in 2030 for a range of internal noise levels in bedrooms of 50, 55, 60, 65 and 70 dB LAs,max. The table shows the number of awakenings for people at those levels on departure and for arrivals for both the 10MPPA and 12MPPA scenarios. The table also shows the predicted increase in awakenings with the 12MPPA scenario compared to 10MPPA; and the same information in terms of awakenings per week and awakenings per year.

TABLE 8: DEPARTURE AND ARRIVAL ADDITIONAL AWAKENINGS FOR A TYPICAL PERSON FOR BOTH THE 10MPPA AND 2MPPA SCENARIOS, THE DIFFERENCE BETWEEN THE SCENARIOS AND THE SAME INFORMATION FOR A WEEK AND A YEAR

	Awakenings per week

66 The WHO community noise guidelines 1999 assume a noise reduction of 15 decibels for a façade with a partially open window.

		Departures 10MPPA	Departures 12MPPA	Arrivals 10MPPA	Arrivals 12MPPA		Departures excess awakenings at 12MPPA compared to 10 MPPA	Arrivals excess awakenings at 12MPPA compared to 10 MPPA
LASmax (internal)	**No Days**	**15**	**19**	**20**	**23**		**19-15**	**23-20**
50	7	3	4	4	5		0.9	0.7
55	7	5	6	7	8		1.3	1.0
60	7	7	9	9	10		1.8	1.4
65	7	9	11	12	13		2.3	1.8
70	7	11	14	15	17		2.9	2.2
	Awakenings per year							
LASmax	**No Days**	**15**	**19**	**20**	**23**		**19-15**	**23-20**
50	365	173	219	231	266		46	35
55	365	259	328	345	397		69	52
60	365	353	448	471	542		94	71
65	365	457	579	610	701		122	91
70	365	571	723	761	875		152	114

7.20. The above figures are for notional locations. In addition, some locations might be affected by arrivals and departures (depending on wind direction affecting the mode of operation of the airport). Therefore, the impact over a week and a year will require adding both sets together according to the modal split.

7.21. The analysis of additional awakenings should have been carried out for real locations and actual levels from aircraft, but the assessment above provides a reasonable estimate of the probable trend i.e. individuals are likely to suffer more additional awakenings with the 12MPPA scenario compared to 10MPPA.

7.22. Tables 6.15 to 6.17 in the AES show the difference in LAeq,t noise levels between the with and without the scheme scenarios in 2030 in the early part of the night from 2300 to 2330 hrs, the main part of night from 2330 to 0600 hrs and the late section of night from 0600 to 0700 hrs. The differences shown are from 0 to 2 dB. Again such apparently small differences in LAeq,T between the with and without scheme scenarios do not provide adequate information to assess the full impacts at night as there is no accompanying information on how often appropriate individual noise event thresholds e.g. N60 will be exceeded.

7.23. However, the original ES did include information on how the N70 and N60 metrics were predicted to be different with and without the scheme in 2026, in tables 7D.36, 7D.37 and 7D.38; and 7D.39, 7D.40 and 7D.41 respectively. These tables show that with the 12MPPA scheme operating the total area, number of dwellings and population affected by the NA70 metric during the day and NA60 noise metric at night would be substantially greater compared to 10MPPA, as summarised in the table below.

TABLE 9: EXTRA AREA, NO OF DWELLINGS AND POPULATION EXPOSED TO NUMBER OF EVENTS ABOVE LAMAX 70 DB (DAYTIME) FOR 12MPPA COMPARED TO 10MPPA IN 2026 FROM TABLES 7D.36, 7D.37 AND 7D.38 IN THE ES

Number of Events above LAmax 70 dB	Additional Area Km² at 12 MPPA compared to 10MPPA 2026	Additional No Dwellings at 12 MPPA compared to 10MPPA 2026	Additional Population at 12 MPPA compared to 10MPPA 2026

10	3.2	300	700
20	2.8	250	650
50	3	100	350
100	3.6	100	300
200	0.6	0	0

Table 10: Extra Area, No of Dwellings and population exposed to Number of events above LAmax60 dB (Night time) for 12MPPA compared to 10MPPA in 2026 from tables 7D.39, 7D.40 and 7D.41 in the ES

Number of Events above LAmax 60 dB	Additional Area Km^2 at 12 MPPA compared to 10MPPA 2026	Additional No Dwellings at 12 MPPA compared to 10MPPA 2026	Additional Population at 12 MPPA compared to 10MPPA 2026
10	12.4	1950	4700
20	11.7	1330	3000
50	0.7	1	2
100	0	0	0
200	0	0	0

7.24. The DOKEN[67] trial at Heathrow provided useful insights on how to measure the noise environment using Number Above metrics. For this trial, N65 (Night 8hr)>25 and N65 (Day 16hr)>50 provided more significant and clearer differences in exposure than Leq differences as they combine an element of noise level and an element related to the degree of overflight. Whilst the data extracted from the ES shown above is for slightly different NA values (70 and 60 for day and night respectively) they do show the clear trend is for the 12MPPA scenario to cause a substantial increase in dwellings and therefore people exposed above similar NA values

[67] DOKEN Trials - Impact of Precise Navigation Flight-Paths on Overflown Residents, Heathrow Airport Ltd, by SYSTRA, Ian Flindell & Associates and Manchester Metropolitan University (September, 2014)

as referred to in the DOKEN trials i.e. considerably greater negative impacts than the 10 MPPA scenario. .

Non-residential receptors

7.25. The AES at paragraph 6.5.40 Appendix 6A identifies only one school, Winford Primary School, as being exposed to 55 dB LAeq,16h or more, under all scenarios.

7.26. However, as discussed above, consideration should also be given to the LA1,30 mi noise metric in regard to impacts on schools and no consideration of this is provided in either the ES or AES.

7.27. At paragraph 6.5.43 the AES reports that there are 35 places of worship identified within the "Zone of influence" of air noise around Bristol Airport. Nine of these were exposed to air noise at or above the LOAEL of 51 dB LAeq,16h in 2017. The situation will remain unchanged in the 10 MPPA 2024 scenario, and reduce to six in both the 2030 scenarios. No places of worship are exposed to air noise at or above the SOAEL of 63 dB LAeq,16h, either in 2017 or in the future.

7.28. However, again no consideration is given to whether using a long duration 16 hr time base and only the LAeq, t metric is appropriate for a place of religious worship which wil be used for shorter durations and where the sense of peace and tranquillity will often be valued, and how often this may be interrupted by additional ATMs as a result of the scheme.

7.29. Paragraph 6.5.45 of the AES reports that there are 24 amenity areas identified within the Zoi of air noise around Bristol Airport. These vary in nature from playgrounds and parks, to open spaces. Nine of these receptors are were exposed to a daytime air noise level of 50 dB LAeq,16h or more in 2017. Only three amenity areas were exposed to a daytime air noise level at or above the LOAEL of 55 dB LAeq,16h or more in 2017, these being Cadbury Hill in Yatton, Vee Lane Play Area in Felton, and Felton Common. Paragraph 6.5.46 goes on to say this situation will remain broadly the same in the future. The number of those areas exposed to 50 dB and 55 dB remains the same in the 10 mppa 2024 scenario, reduces to eight and three respectively in the 12 mppa 2030 scenario, and reduces to eight and two (Vee Lane Play Area and Felton Common) in the 10 mppa 2030 scenario. However, this analysis is not sophisticated enough as it uses only the LAeq,16 noise metric, does not recognise any difference in the perceived amenity of each of these spaces and how aviation noise impinges on the use of each area, and whether the increase in individual noise events due to more ATMs because of the scheme might degrade the amenity value. In particular there is no attempt to assess the tranquillity at each of the amenity locations identified and evaluate how this might change.

Apparent anomalies in the noise data

7.30. Scrutiny of the supporting Full Modelling Output data in the appendices to the AES raises several issues relating to the population count tables of persons Highly Annoyed and % Highly Sleep Disturbed follows.

Day time - Annoyance

7.31. There appears to be discrepancies in the number of person likely to be Highly Annoyed in table 6.20 of the Appendices of the Addendum ES, which is reproduced below;

TABLE 11: TABLE 6.20 FROM THE AES APPENDICES FULL MODELLING OUTPUT DATA

ES	Table 6A.20 Highly annoyed population count, $L_{Aeq,16h}$ average mode summer day			
Contour Band	%HA	10 mppa 2024	12 mppa 2030	10 mppa 2030
51 - 54	8	450	400	350
54 - 57	11	150	100	100
57 - 60	15	100	100	100
60 - 63	20	50	50	30

63 - 66	27	10	10	10
66 - 69	35	1	1	1
Total1		750	700	600

7.32. Logically is showing the highly annoyed population count table 6A.20 should broadly follow the trends in Tables 6A.11, 6A.12 and 6A.13 that respectively show for the year 2030 the predicted area covered by the noise contours, the number of dwellings and the number of persons within those contours is greater for the 12MPPA scenario than for the 10MPPA scenario.

7.33. However, in the 54-57 dBA and 57-60 dBA contours, table 6.13 shows that the number of persons is fewer for the 10 MPPA scenario than for the 12MPPA scenario. Nevertheless, table 6A.20 shows the same number of persons are predicted to be highly annoyed, whereas application of the same % percentage annoyed to both scenarios should see fewer people annoyed at 10MPPA because there are fewer people in this noise band compared to the number predicted at 12MPPA.

7.34. In order to try and understand this apparent discrepancy better, the data in table 6A.13 of population exposure has been disaggregated from cumulative values i.e. the counts include all those dwellings or people within a specified contour band; so, for example the number dwellings within a 60 dB contour includes those within the 63 dB, 66 and 69 dB bands as well; to the actual number of persons in each noise band.

7.35. The disaggregated number of persons in each noise band has then been combined with the percentage highly annoyed in Table 6A.20 to re-calculate the number of persons highly annoyed in each noise band; as shown in the revised table below:

TABLE 12: TABLE 6A.20 RECALCULATED USING DISAGGREGATED NUMBER OF PERSONS IN EACH NOISE BAND

	Revised Table 6A.20 Highly annoyed population count, $L_{Aeq,16h}$ average mode summer
Disaggregated	day

Contour Band	%HA	10 mppa 2024	12 mppa 2030	10 mppa 2030
51 - 54	8	444	420	360
54 - 57	11	132	121	110
57 - 60	15	113	120	98
60 - 63	20	50	52	32
63 - 66	27	13	10	10
66 - 69	35	1	1	1
Total[1]		752	724	611

7.36. This analysis shows that table 6A.21 in the AES consistently underestimates the number of annoyed persons in several contour bands, up to 63 dB noise contour, then the presented numbers of people are correct.

7.37. In addition, the following appear to be anomalous:

- There are more people in the 54 dB and 57 dB contours for the 2030 12MPPA scenario compared to 2030 10MPPA scenario in table 6A.13, but the same number of persons annoyed in each band for both scenarios in table 6A.21, with a greater total number of persons annoyed in 2030 for the 10MPPA scenario, and;
- The totals of annoyed persons for each scenario in table 6A.20 are incorrect based on the numbers presented in the column for each scenario.

Night time % Highly Sleep Disturbed

7.38. The above analysis is not possible for the night time data and the % Highly Sleep disturbed because the tables 6A.14, 6.A.15 and 6A.16 showing the noise contours size, no of dwellings in each noise contour and number of people in each noise contour respectively are in 3 decibels bands, but the table 6A.21 showing the number of people highly sleep disturbed is in 5 decibel bands.

7.39. However, unlike the daytime tables, the tables for night time are not cumulative i.e. they show the data for each noise band only. Consequently, it is anomalous that tables 6A.15 and 6A.16 show:

- Inconsistent assumed occupancy rates in dwellings. Dividing the population by dwellings for each noise band gives different numbers of persons per dwelling ranging from 2.14 to 3.0.
- Regarding the 57 decibel contour, the number of dwellings in table 6A.15 increases between 10MPPA and 12MPPA, but the population exposed in this noise band in table 6A.16 is the same.

7.40. In addition, regarding Table 6A.21 which shows the predicted number of persons likely to be Highly Sleep Disturbed, unfortunately:

- The total Highly Sleep Disturbed Population Count provided for each of the three scenarios doesn't add up to the sum of the number of persons in each noise band; and,
- Despite the area, number of homes and number of persons covered by each of the night noise contours being greater for the 12MPPA scenario compared to the 10MPPA scenario in 2030, the total Highly Sleep Disturbed Population count is lower for the 12MPPA scenario compared to 10MPPA in 2030.

7.41. Consequently, the above raised the following questions.

- Why the true number of annoyed persons is higher/different than the AES shows?
- Why are more people predicted to be highly sleep disturbed with the 10MPPA scenario compared to the 12MPPA scenario in 2030, although the total area, number of homes

and number of persons covered by the night noise contours is greater for the 12MPPA scenario?

- Alternatively, if table 6A.21 is incorrect please can a correct table be provided as soon as possible for the correct picture to be taken into account in deciding this matter.

7.42. The above questions were put to the appellant and they responded by email to say:

Table 6A.21 is incorrect. It has erroneously included data for 2017 as the first column which displaced the other columns. Table 6.11 in the main report of the ES Addendum does however give the correct totals so this should not affect any conclusions drawn from the results. A corrected version of 6A.21 is provided below:

Corrected Table 6A.21 Highly sleep disturbed population count, L_{night} average mode annual night

Contour Band L_{night} (dB)	**% Highly Sleep Disturbed**	**Highly Sleep Disturbed Population Count**		
		10 mppa 2024	**12 mppa 2030**	**10 mppa 2030**
45 - 50	6	350	350	300
50 - 55	9	100	100	90
55 - 60	12	20	20	20
60 – 65	16	0	0	0
65+[1]	19	0	0	0
Total[2]		450	500	400

1. Data included for completeness. Sleep disturbance data normally confined to 45 to 65 dB Lnight for accuracy.
2. Total based on unrounded data.

And

There is no inconsistency between the 10 mppa 2030 and 12 mppa 2030 scenarios in Tables 6A.11 to 6A.13 – the 12 mppa results are the same or greater for every contour band.

In relation to Table 6A.13, the 54-57 dB contour band, the number derived from Table 6A.13 would be 1100 for 12mppa 2030 and 1000 for 10mppa 2030. For the 57-60 dB band, these numbers are 800 for 12 mppa 2030 and 650 for 10 mppa 2030.

There seems to be a misunderstanding that the values presented in the ES and ESA have been rounded, as mentioned above. In the interests of transparency, I provide below the unrounded versions of Tables 6A.20 and 6A.21. Unrounded Table 6A.20 Highly annoyed population count, $L_{Aeq,16h}$ average mode summer day

Contour Band $L_{Aeq,16h}$ (dB)	% Highly Annoyed	Highly Annoyed Population Count		
		10 mppa 2024	12 mppa 2030	10 mppa 2030
51 - 54	8	442	422	361
54 - 57	11	135	119	109
57 - 60	15	110	118	99
60 - 63	20	53	53	29
63 - 66	27	11	11	10
66 - 69	35	1	1	1
Total		753	724	610

Unrounded Table 6A.21 Highly sleep disturbed population count, L_{night} average mode annual night

Contour Band L_{night} (dB)	% Highly Sleep Disturbed	Highly Sleep Disturbed Population Count		
		10 mppa 2024	12 mppa 2030	10 mppa 2030
45 - 50	6	345	351	301
50 - 55	9	107	115	90
55 - 60	12	20	24	17
60 – 65	16	0	0	0

65+[1]	19	0	0	0
Total		472	489	409

1. Data included for completeness. Sleep disturbance data normally confined to 45 to 65 dB Lnight for accuracy.

Para 1.9 states that:

"unlike the daytime tables, the tables for night time are not cumulative i.e. they show the data for each noise band only"

This is incorrect. Tables 6A.15 and 6A.16 are cumulative.

7.43. The clarification confirms that in 2030 when compared to the 10 MPPA scenario the 12MPPA scheme will result in more people being exposed to increased aviation noise between LOAEL and SOAEL during the day; and between LOAEL and SOEAL, and Above SOAEL at night.

8. GROUND NOISE IMPACTS OF THE PROPOSALS

8.1. In the AES Table 6.19 Ground noise dwelling counts, LAeq,16h average summer day shows that an additional 10 dwellings in the 2030 with scheme scenario are predicted to experience ground noise above the LOAEL level adopted in the ES compared to the 2030 without scheme scenario. The same number of properties are predicted to be exposed to ground noise above the SOAEL adopted in the ES for both the with and without scheme scenarios in 2030.

8.2. Table 6.20 Ground noise dwelling counts, LAeq,8h average summer night shows that 10 fewer properties are predicted to be exposed to noise above LOAEL at night in the with scheme scenario compared to the no scheme situation in 2030. Conversely, an additional property is predicted to be exposed above the SOAEL for ground noise adopted in the ES in the with scheme scenario compared to without the scheme.

8.3. However, the assessment of ground noise in the ES and AES is not considered adequate and the finding that there would be no significant effects is considered unreliable for the following reasons.

- The assessment criteria used in the ES do not take account features of the noise that enhance its impact such as intermittency, tones and/or substantial low frequency content[68].
- The use of long term LAeq 16 hr and 8hrs for assessment of day and night effect respectively will "average down" the intermittent periods of ground noise of higher levels but shorter duration during these times. Consideration should also given to the effects of the actual level of noise during each episode of ground noise e.g. sleep disturbance,

[68] As per the advice of the NPPG and the IEMA guidelines for the assessment of environmental noise

speech and activity disturbance, the number of such episodes in each 16 hr day and 8 hr night period, and the peak noise level of each event.

- The information in tables Table 6.21 Ground noise exposure levels at representative residential locations, LAeq,16h summer day, and Table 6.22 Ground noise exposure levels at representative residential locations, LAeq,8h summer night; showing absolute noise levels and the difference in 2030 between predicted with and without the 12 MPPA scheme which shows a mixture of some of the identified locations experiencing an increase and others a decrease in these metrics because of the scheme. However, an informed judgement as to the overall balance of adverse versus positive impacts based on the numbers of persons likely to experience a reduction and those likely to suffer an increase in ground noise is not possible as only the general receptor locations are provided and no information on the number of affected properties or likely number of persons is given.

9. CONDITIONS

9.1. The following noise related conditions are considered necessary

Numbers of Air Traffic Movements

9.2. To manage the potential trading off, of individually slightly less loud aircraft for a greater number of still noisy ATMs inherent in the energy averaging of the LAeq,T noise metric used to develop noise contours, there needs to be a cap on the number of ATMs at the airport.

9.3. To manage the potential trading off, of individually slightly less loud aircraft for a greater number of still noisy ATMs inherent in the energy averaging of the LAeq,T noise metric used to develop noise contours, there needs to be a cap on the number of ATMs at the airport.

9.4. A limit of 75,500 ATMs in any 12 month period can be taken from paragraph 3.2.7 of the Addendum ES.

9.5. A 25% flexibility will give the airport capacity to vary the daily ATM cap, but limit any impact on the LAeq,T noise levels to an increase of no more than around 1 dB LAeq,T. But because the annual limit is fixed, the number of ATMs in other 24 hr periods will have to be reduced to compensate and avoid breaching the rolling 12 month control value.

9.6. The overall limit on the number of night ATMs would stay as applied for by BAL.

9.7. A condition based on the above could be worded as follows:

- There shall be no more than 75,500 Air Transport Movements (ATM's) at Bristol Airport which includes take-off and landing movements, from 1 January to 31 December each year. Furthermore, not more than 207 ATM's shall take place in any 24-hour period, of which not more than 32 ATMs shall be between 23:00 Hours to 07:00 Hours within a 24-hour period, except the 24 hour limits may be exceeded by up to 25%: that is up to 259 ATM's over a 24-hour period; with up to 40 of these ATM's between 23:00 Hours to 07:00 Hours; on not more than 92 occasions from 1 January to 31 December each year.

The airport operator shall provide quarterly reports in writing to the local planning authority, within 28 days of the last day of each quarterly period, to show the quarterly and cumulative figures for each category comply with these limits and set out the steps it proposes to implement in order to prevent any exceedances of these limits in the next quarter. Once approved, those details shall be implemented and retained until superseded by any subsequently approved details.

For the purposes of this condition non-commercial movements (e.g. positioning flights and general aviation) are to be included in the total annual movements limits.

For the purposes of this condition, the limit to ATMs shall not apply to aircraft taking off or landing in the airport because of an emergency, instruction from Air Traffic Control or any other circumstance beyond control of the airport operator. REASON: Reason: To reduce the impacts of aircraft noise in accordance with policies CS3 and CS23 of the North Somerset Core Strategy and Policy DM50 of the North Somerset Council Sites and Policies Plan Part by ensuring the noise impacts and effects of the development are no worse than predicted in the Environmental Statement and Addendum for the permitted scheme.

Noise contour area

9.8. The size of the noise contours associated with the proposed increase in ATMs/passenger capacity needs to reflect the effects assessed in the ES/AES. The contours sizes proposed by are larger than assessed in the ES/AES to allow for "uncertainty" in the future size of the contours, but the effects of these larger sizes i.e. total area, number of properties and person affected, are not assessed in either the ES or AES.

9.9. Conditions taking account the actual area f noise contours assessed in the ES could be worded as follows:

The area enclosed by the 51 dB LAeq, 16hr (07:00 hours - 23:00 hours) and 4 dB LAeq 23:00 Hours to 07:00 Hours noise contours, when calculated by the Aviation Environmental Design Tool (AEDT) Version 2.0d (or as may be amended) over a 92-day period between 16th June and 15th September, shall not exceed the areas provided below; using the standardised average mode from the date of grant of this permission.

Area covered by the 51dB(A) LAeq, 16hr (07:00 hours - 23:00 hours) noise contour

- Up to 10 MPPA 2024 no more than 37.1 Km^2
- Up to 10 MPPA 2030 no more than 30.7 Km^2
- Up to 12 MPPA 2030 no more than 35.2 Km^2

Area covered by the 45 dB(A) LAeq, 2300 to 0700 hours) noise contour

- Up to 10 MPPA 2024 no more than 47.8 Km^2
- Up to 10 MPPA 2030 no more than 42.4 Km^2
- Up to 12 MPPA 2030 no more than 50 Km^2

Reason: To reduce the impacts of aircraft noise in accordance with policies CS3 and CS23 of the North Somerset Core Strategy and Policy DM50 of the North Somerset Council Sites and Policies Plan Part 1.

Note

The areas quoted here are those assessed in the AES. The BAL conditions propose larger areas to allow for "uncertainty" in the future size of the contours, but the impacts of these bigger contours are not assessed in either the ES or ESA.

20. The area enclosed by the 63, 60, 57, 54 and 51 dB(A) Leq 16hr (07:00 hours to 23:00 hours) noise contours and the 55 and 40 dB LAeq,8hr summer night time noise contour (23:00 hours to 07:00 hours) for the forthcoming year (from 1 January to 31 December each year) shall be reported to the Local Planning Authority annually within the Annual Operations Monitoring Report.

The same report shall include comparison of the predicted noise levels at the Noise Monitoring Terminals based on the forecast noise contours for the previous year with the 92 day averaged summer measured noise levels at the NMTs.

Reason: To ensure that the size of these noise contours and the numbers of properties and people affected is regularly reported so that the noise impacts of Bristol Airport's growth can be identified, checked against the limits attached to this permission, and noise mitigation can be applied appropriately, and in accordance with policies CS3 and CS23 of the North Somerset Core Strategy and Policy DM50 of the North Somerset Council Sites and Policies Plan Part 1.

Reason: To ensure that the size of these noise contours and the numbers of properties and people is regularly reported so that the noise impacts of Bristol Airport's growth can be identified, and noise mitigation can be applied.

Night Flying

9.10. A Quota Count (QC) system is used in conjunction with an overall cap on the number of flights at night to restrict the aircraft types that use the airport at night so that the noisiest aircraft are prohibited and ensure that the aircraft that are allowed to fly at night fit into defined categorise that describe how noisy they are so that an overall noise "dose" is not breached. The QC system allows each night flight to be individually counted against an overall noise quota (or noise budget) for an airport according to the QC rating (i.e. the noisiness) of the aircraft used.

9.11. Under the QC system, each aircraft type, including different versions of the same model, is assigned a Quota Count according to its noise performance, separately for arrival and departure.

9.12. A difference in noise levels of 3 decibels represents a doubling or halving of noise energy. Consequently, the existing QC system based on 3 decibel bands means it works on the principle that an aircraft classified QC/1 has half the noise energy as an aircraft classified QC/2 and twice the noise energy as aircraft classified QC/0.5. However, this is only approximate as aircraft rated at 90.1 EPN dB in the bottom of QC 1 and 95.9 EPN dB at the top of QC 2 would differ by 5.8dB, representing almost a four-fold difference in noise energy, but a difference in QC of only 1. This can lead to an underestimation of the size of the night time noise contours and therefore people affected, although the aircraft may comply with the QC system.

9.13. To reduce the risk of the above happening the proposed condition should be changed so the banding of the QC system was in 1 dB steps (as used at London City Airport), as shown in the table in the draft condition below.

Night Flying:

(a) In this condition and the three following conditions:

"airport manager" means the person (or persons) for the time being having the management of Bristol Airport or persons authorised by such person or persons;

"maximum certificated weight" means the maximum landing weight or the maximum take-off weight, as the context may require, authorised in the certificate of airworthiness of an aircraft;

"designated aerodromes" means by virtue of the Civil Aviation (Designation of Aerodromes) Order 1981(a) Heathrow Airport - London, Gatwick Airport London and Stansted Airport - London ('the London Airports') are designated aerodromes for the purposes of Section 78 of the Civil Aviation Act 1982 ('the Act');

"quota" means the maximum permitted total of the quota counts of all aircraft taking off from or landing at Bristol Airport in question during any one season between 23.30 hours and 06.00 hours, and

"quota count" means the amount of the quota assigned to one take-off or to one landing by any such aircraft, this amount being related to its noise classification as specified below;

"the summer season' means the period of British Summer Time in each year as fixed by or under the Summer Time Act 1972, and

"the winter season" means the period between the end of British Summer Time in one year and the start of British Summer Time in the year next following.

(b) For the purpose of this condition:

(i) the noise classification of any aircraft shall be that set out as per those defined for designated aerodromes;

(ii) subject to paragraph (i) and (iii), the quota count of an aircraft on take-off or landing shall be calculated on the basis of the noise classification for that aircraft on take-off or landing, as follows:

Noise Level Band EPN dB	**Quota Count (QC) Classification**
>102	**16**
101 – 101.9	**8**
100 – 100.9	**6.7**
99-99.9	**5.4**
98 – 98.9	**4**
97- 97.9	**3.4**
96 – 96.9	**2.8**
95 – 95.9	**2**
94 – 94.9	**1.7**
93 – 93.9	**1.4**
92 – 92.9	**1**
91 – 91.9	**0.83**

90 – 90.9	**0.69**
89 – 89.9	**0.5**
88 – 88.9	**0.42**
87 – 87.9	**0.34**
86 – 86.9	**0.25**
85 – 85.9	**0.21**
84 – 84.9	**0.17**
83 – 83.9	**0.125**
82 – 82.9	**0.085**
81 – 81.9	**0.045**
80 – 80.9	**0.025**
<80	**0.0125**

(iii) Exempt aircraft are –

those jet aircraft with a maximum certificated weight not exceeding 11,600 kg,

those aircraft, which, from their noise data, are classified at less than 81 EPNdB shall not count towards the quota.

(c) For the purposes of this condition, an aircraft shall be deemed to have taken off or landed at the time recorded by the Air Traffic Control Unit of Bristol Airport.

(d) This condition shall take immediate effect at the start of the first full season (being the winter season or the summer season) following the commencement of development. Subject to the following provisions of this condition, the quota for the summer season shall be 1260, and the quota for the winter season shall be 900.

(e) An aircraft with a quota-count of 2 or above shall not:

(i) be scheduled to take off or land during the period 23.00 hours to 06.00 hours;

(ii) be permitted to take off during the period 23.00 hours to 06.00 hours except in circumstances where: it was scheduled to take off prior to 23.00 hours; and take-off was delayed for reasons beyond the control of the air traffic operator.

(f) An aircraft shall not be permitted to take off or be scheduled to land during the period 23:30 hours to 06:00 hours where:

(i) the operator of the aircraft has not provided (prior to its take-off or prior to its scheduled landing time as appropriate) sufficient information (such as aircraft type or registration) to enable the airport manager to verify its noise classification and thereby its quota count; or

(ii) the operator claims that the aircraft is an exempt aircraft, but the aircraft does not, on the evidence available to the airport manager, appear to be an exempt aircraft.

(g) If any part of that quota remains unused in any one season, the amount of the shortfall up to a maximum of 10% shall be added to the quota for the subsequent season.

(h) The 10% value expressed in (g) shall be reduced on a progressive basis in accordance with the following schedule:

Timeline	**% Quota** **Maximum carry-over allowance from unused quota points from the preceding season only**
In the first 2 seasons which begin 12 months after the commencement of development.	8%
In the 2 seasons which begin 2 years after the commencement of development.	6%

In the 2 full seasons which begin 3 years after the commencement of development.	4%
In the 2 full seasons which begin 4 years after the commencement of development.	2%.
In the 2 full seasons which begin 5 years after the commencement of development.	0%. This is then retained in perpetuity

(i) An aircraft shall not be permitted to take off or be scheduled to land during the period 23.00 hours to 07.00 hours where:

(i) the operator of the aircraft has not provided (prior to its take-off or prior to is scheduled landing time as appropriate) sufficient information (such as aircraft type or registration) to enable the airport manager to verify its noise classification and thereby its quota count; or

(ii) the operator claims that the aircraft is an exempt aircraft, but the aircraft does not, on the evidence available to the airport manager, appear to be an exempt aircraft.

(j) This condition shall not apply to any take-off or landing, which is made:

(i) where the airport manager decides, on reasonable grounds, to disregard for the purposes of this condition a take-off or landing by a flight carrying or arriving to collect cargoes, such as medical supplies, required urgently for the relief of suffering, but not cargoes intended for humanitarian purposes where there is no special urgency;

(ii) where the airport manager decides to disregard for the purposes of this condition a take-off or landing in any of the following circumstances:

- delays to aircraft, which are likely to lead to serious congestion at the aerodrome or serious hardship or suffering to passengers or animals;
- delays to aircraft resulting from widespread and prolonged disruption of air traffic;
- where an aircraft, other than an aircraft with a quota count of 4 or above, is scheduled to land after 06:30 hours but lands before 06:00 hours;

Provided that, for the avoidance of doubt, where an aircraft is scheduled to land between 06.00 hours and 06.30 hours but lands before 06.00 hours, that landing shall count towards the quota.

It shall be the duty of the airport manager to notify the Local Planning Authority in writing, within one month from it occurring, of any occasion (whether a single occasion or one of a series of occasions) to which this paragraph applies.

(k) This condition shall not apply to any take-off or landing which is made in an emergency consisting of an immediate danger to life or health, whether human or animal.

Reason: To ensure that the proposed development does not give rise to unacceptable levels of night noise in accordance with Policy CS3 of the North Somerset Core Strategy and Policy DM50 of the North Somerset Sites and Policies Plan Part 1.

- The total number of aircraft movements at the airport including take-offs and landings between the hours of 23:30 hours and 06:00 hours for 12 months (for the avoidance of doubt this will be two adjoining seasons of Summer and Winter) shall not exceed 4000. For the purposes of this condition flights falling within the categories listed in condition 18 sub-clause j and k shall not be included. For clarity, a take-off or a landing shall comprise 1 movement.

Reason: To reduce the noise impact of night-time flights on the living conditions of residents in accordance with policies CS3 and CS23 of the North Somerset Core Strategy and Policy DM50 of the North Somerset Replacement Local Plan.

- The total number of take-offs and landings between 06:00 hours and 07:00 hours and between 23:00 hours and 23:30 hours (the 'shoulder periods') shall not exceed 9,500 in any calendar year. For the purposes of this condition, flights falling within the categories listed in 18 sub-clause j and k shall not be included.

Reason: To reduce the noise impact of night-time flights on the living conditions of residents during the 'shoulder periods' in accordance with Policies CS3 and CS23 of the North Somerset Core Strategy and Policy DM50 of the North Somerset Sites and Policies Plan Part 1.

Ground Noise

9.14. BAL want to be able to use Auxiliary Power Units (APUs)[69] from 0600, but that is the last hour of the normal night period from 2300 to 0700 when people will tend to be in the lighter stages of sleep and more susceptible to noise. The condition below extends the ban on use of APUs to the whole of the night period.

- Auxiliary Power Units shall not be used on stands 38 and 39 as shown on the approved plans between the hours of 23:00 and 07:00.

  Reason: To reduce the noise impact of ground-based operations on the living conditions of residents and accordance with policies CS3 and CS23 of the North Somerset Core Strategy and Policy DM50 of the North Somerset Sites and Policies Plan Part 1.

106 Agreement

9.15. With regard to the 106 agreement the following is considered necessary in relation to the noise insulation scheme.

- The owner covenants to submit a noise mitigation scheme to the local planning authority for approval and to not implement any planning permission to increase passenger numbers above 10 million per year until a noise mitigation scheme has been approved by the local planning authority.

- The owner covenants that the noise mitigation scheme submitted for approval shall include the following:

  a. That residential properties located within the 54 dB, 57dB, 60 dB and 63 dB (A) LAeq, 16hr (07:00 – 23:00) contours, the 45 dB (A) LAeq, 8hr (23:00 to 07:00) contour shall be eligible for noise mitigation grants amounting to 100% of the costs

[69] The APU is a small turbine engine typically installed near the rear of the fuselage. An aircraft APU serves as an additional energy source normally used to start one of the main engines on an airliner or business jet. The APU is equipped with an extra electrical generator to create enough power to operate onboard lighting, galley electrics and cockpit avionics, usually while the aircraft is parked at the gate. Drawing bleed air from its own compressor, an APU also drives the environmental packs used to heat and cool the aircraft.

of providing noise insulation, suitable alternative means of ventilation and prevention of overheating to all habitable rooms, and kitchens used for dining, in qualifying properties.

b. The noise mitigation measures included in any noise insulation scheme shall be supported by evidence of in-situ testing of effectiveness against aircraft noise.

c. As well as noise insulation measures the scheme shall include measures to provide suitable alternative means of ventilation and prevention of over heating where appropriate and necessary.

d. The noise insulation scheme shall be based on a survey of each affected property and be designed to achieve within the context of the individual properties the recommended day and night internal LAeq,t noise levels from BS 8223:2014 without any 5 decibel uplift; and an LAmax due to aircraft noise intrusion of no more than 45 dBA in bedrooms between 2300 and 0700 hrs no more than 10 times.

10. CONCLUSIONS

10.1. Table 6.26 in the AES provides a summary of the significance of effects. For each noise source considered the opinion offered is that the likely effect is "*Not significant*".

10.2. The rationale for finding that the noise impacts will not be significant is broadly that the ES and AES found there are no receptors subject to significant operational noise and vibration effects due to the change between the 'Without Development' (10 mppa) and 'With Development' (12 mppa) scenarios.

10.3. Unfortunately, the basis for the AES and ES conclusion that no significant adverse noise effects are likely is considered unsafe for reasons including the following:

- Use of the LAeq,T metric is appropriate, but not as the sole metric against which to assess the significance of noise effects. In addition, Number Above 60 dB and 70 dB, Single mode contours, which assume either 100% easterly or westerly operations, should also be considered; and for night time noise and assessment of impacts on schools consideration of awakenings using the LAFmax, SEL and LAsmax metrics respectively should also be used.

- Established direct impacts of aviation noise on health such as cardiac effects, stroke, hypertension etc. are not evaluated in either the ES or AES noise or human health chapters. The ES and AES both show that in 2030 noise from the 12MPPA scheme will affect a wider area, a greater number of dwellings and more people than the 10MPPA scheme. Consequently, the attendant risks of direct health effects of aircraft noise are greater for the 12 MPPA scheme than for 10MPPA.

- Air noise impact ratings - change in noise level, outdoors used in the ES and addendum underestimates the degree of impact of small increases in LAeq16 hr day and LAeq8 Hr night noise levels caused by substantial increases in numbers of ATMs.

- The fleet mix in future is likely to retain a larger proportion of noisier aircraft and a smaller proportion of the less noisy aircraft types than assumed in the noise predictions for the ES and AES. This means that the future noise levels could be higher than assessed in the ES and AES and affect a greater number of people more adversely than described in the ES and AES.

- The proposed development results in a worsening of an already stressed and adverse and significantly adverse noise environment for the local community and not the improved one which the APF and MBU requires to be delivered if additional use of existing capacity is to be permitted.

10.4. However, notwithstanding the issues described above, it is also considered that the findings of the ES and AES that there are no receptors subject to significant operational noise and vibration effects due to the change between the 'Without Development' (10 mppa) and 'With Development' (12 mppa) scenarios is over optimistic because as described in detail in the preceding section of this evidence the Proposed Development would:

- Increase the number of people experiencing significant adverse and adverse impacts on health and quality of life from air noise e.g. with the 12MPPA scenario in 2030 an additional 247 persons are predicted experience an increase in noise to above SOAEL at night compared to 10 MPPA; and 1100 and 4000 more persons respectively above LOAEL during the day and at night .

- Not sufficiently mitigate and minimise adverse impacts on health and quality of life e.g. the proposed noise insulation scheme is insufficient in terms of spatial scope and only addresses internal noise impacts and not those in private and public outdoor amenity spaces; at the cost of requiring residents to keep windows closed which is itself a significant adverse impact on quality of life in rural and locations that would other wise be relatively quiet.

- Contribute to a deterioration in health and quality of life by worsening significant adverse and adverse effects of noise associated with the operation of the airport
- Not ensure that impacts are reduced to an acceptable level since the population adversely impacted by noise increases, including those experiencing noise above SOAEL
- Not demonstrate satisfactory resolution of impacts, particularly those on surrounding communities
- Not contribute to improving the health and well being of the local population; rather it contributes to a reduction in health, well-being and quality of life of the local population

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