Deadline 5 Submission

This Deadline 5 submission contains three elements:

1. **Need & Operations:** Applicant and Public Authority responsibilities pursuant to Case Law Hatton and others v. United Kingdom that shows Article 8 of the European Convention on Human Rights to apply in cases of aircraft noise. Observations communicated at the Need & Operations Issue Specific Hearing of 21 March 2019.

   Please note Article 13 of the Human Rights Convention also applies and will be discussed in a future submission

2. **Night Flights:** Kent County Council's position on night flights as relate to Gatwick Airport and correspondence with Paul Carter, Leader, Kent County Council regarding the current application

3. **Evidence** as relates to the above (submitted to the ExA as separate attachments):

   a. CASE OF HATTON AND OTHERS v. THE UNITED KINGDOM, *(Application no. 36022/97),* GRAND CHAMBER, European Court of Human Rights

   b. World Health Organisation Environmental Noise Guidelines

   c. Kent County Council response to Airports Commission consultation 3 Feb 2015
   d. Kent County Council response to UK Airspace Policy Consultation
   e. Kent County Council submission to Department for Transport consultation on night flights
   f. Kent County Council policy on Gatwick Airport proposal for a second runway.

Need & Operations; Applicant and Public Authority responsibilities pursuant to Case Law Hatton and others v. United Kingdom that shows Article 8 of the European Convention of Human Rights to apply in cases of aircraft noise. Observations from the Need & Operations Issue Specific Hearing

I would like to thank the Examining Authority for running an open and transparent process and allowing me this opportunity to speak.

Need & Operations

The hearing today has focused on Need & Operations and we have heard a lot of debate from both sides. Leading National Aviation experts have been present, and shared their knowledge of the UK airfreight market. I believe that amidst the debate today it is incumbent on the Applicant to show a pressing social need for their project.

It is safe to conclude that few present today will leave this room with clarity on what that pressing social need is, particularly given the concerns raised regarding the reliability and viability of the Applicant's forecasts and business plan.

We have heard a great deal today about:

- London Heathrow's plans for a third runway and the significant increase to UK airfreight capacity that this will deliver
- Stanstead's plans for expansion and the increase to UK airfreight capacity that will ensue
- The importance of location
- The importance of cost
- The relationship between bellyhold and dedicated airfreight in driving the UK airfreight market & trends.

We have also heard that:

- Airports in the MAG group including East Midlands airport have excess capacity now. Indeed, MAG are clear that they can meet the UK's airfreight needs for the next thirteen years (evidence provided in a previous submission).

What we haven't heard from the Applicant is an articulation of pressing social need that the National Aviation experts present agree on. Indeed, at this point it is now very unclear to me what need the applicant is seeking to fill.

There has been repeated reference that night flights are now out of scope of the Applicants plans (per Isabella Tafur, Barrister for the Applicant). I would request clarity on this point. Are night flights in, or out?

If out, can the Examining Authority clarify with the Applicant:

- Has the impact been modelled in the Applicant's forecasts and benefits case?
- Is the impact on profitability understood?
- Have the investors been informed and have they reviewed the impact to their investment decisions?
- Has this change in scope been formalised with the Examining Authority? And
- Has the Examining Authority made relevant changes its side to formalise this change in scope?

Can the ExA also please clarify from the Applicant in light of their persistent history of misleading the public and local media regarding night flights, what the ATM quotas are that the Applicant is pursuing:

- For night flights
- For daytime flights for cargo
- For daytime flights for passenger flights
- For General Aviation

Also, the % market share each of the above equates to for the relevant market (i.e. dedicated UK cargo market for cargo flights; UK passenger flight market for passenger flights; and so forth).

Human Rights

What IS clear is that behind this lack of clarity and clear articulation of pressing social need are Human Rights issues. We have heard today about SHP's Human Rights as legal owner of the land. What has not yet been discussed are the Human Rights of the residents of Ramsgate and Herne Bay.

Under Article 8 of the Human Rights Act: **Right to respect for private and family life:**

1. Everyone has the right to respect for his private and family life, his home and his correspondence
2. There shall be no interference by a public authority with the exercise of this right except such as is in accordance with the law and is necessary in a democratic society in the interests of national security, public safety or the economic well-being of the country, for the prevention of disorder or crime, for the protection of health or morals, or for the protection of the rights and freedoms of others.

Case Law Hatton and others v. United Kingdom shows Article 8 to apply in cases of aircraft noise. Pursuant to this it is incumbent on the Applicant to demonstrate pressing social need, and the Government and its public authorities to establish proportionality; in other words that that the infringement of human rights is outweighed by the public interest.

The infringement on respect for Ramsgate homeowners' private life and home is clear. This application will result in:

- A night time quota of 3028 ATMs per annum (8.3ATMs per night). Based on night hours of 11pm and 7am (8 hours) this quota means **at least 1 ATM per hour** through the night 365 days a year, **from zero today and zero for the last 5 years**
- A day time quota of 23,340 ATMs per annum (average of 4 ATMs per hour between the hours of 7am and 11pm). That would be **one ATM every 15 minutes** between 7am and 11pm, 365 days a year, **from zero today and zero for the last 5 years**
- Potentially 83,220 ATMs per annum which equates after night flights to an average of 13.7 ATMs per hour between the hours of 7am and 11pm. That would be **one ATM every 4.4 minutes** between 7am and 11pm, 365 days a year, from zero today and zero for the last 5 years
- Each ATM will create noise over the communities of either Ramsgate or Herne Bay >90 dBA Lmax.

The impact of this proposal to our communities will be:

- Constant interrupted sleep
- Higher levels of ill health and consequential impact on local health services
- Constant interruption of children's lessons at schools; up to four times per hour lesson
- Increased risk to personal safety, particularly for those living in the areas that should be classified as PSZ
- Loss of income, particularly for those whose jobs rely on tourism
- Loss in the value of peoples' homes
- Cost of glazing; roof insulation and other sound-proofing requirements (e.g. blocking chimneys)
- To prevent peoples' enjoyment of their gardens
- To force people to live behind closed windows unable to enjoy the sea air, or regulate heat in their homes on hot days and nights.

Hatton and others v United Kingdom suggests that the outcome of a lawsuit under Article 8 will reside on whether the Government can be said to have struck a fair balance between those interests (i.e. economic interests of the country) and the conflicting interests of the persons affected by noise disturbances" (§ 122)

Conclusion

'Today' is the Need & Operation Issue Specific Hearing, week 10 of this resource intensive process. It is currently the only Issue Specific Hearing at which need will be addressed and is therefore crucial for the legal land owner and those of us adversely impacted by this scheme to obtain clarity of what is proposed and what it will mean for us.

Today there has been no clear articulation of need by the Applicant that national aviation experts can agree on. There has been no articulation by the Applicant of *pressing social need* for this Project. Indeed, it is unclear at this point what the scope of this project is. As the audio recordings of today's events will show, the Applicant has been unclear on need for night flights, unclear on the size, nature and business drivers of the dedicated airfreight market, has no prospective customers or clear demand for its services and has proven itself unable to confirm that they have assessed the viability of their proposed Operations. On the other hand, national aviation experts have been clear that they do not believe the Applicant's plans to be viable.

I would respectfully suggest that it is therefore impossible for the Planning Inspectorate (HMG) to establish economic benefit to the Country of the Applicant's proposed scheme as it currently stands, or consequently a view of proportionality to justify the infringement of Ramsgate and Herne Bay residents' human rights under Article 8 of the European Convention for Human Rights. For this same reason, it is also impossible to categorise this application as a NSIP.

If this application is to proceed further, I would urge the Examining Authority to request the Applicant to reassess the budget allocated to compensate for the infringement of residents' human rights and to provide a clear benchmark of their compensation scheme as compared to other NSIP / Infrastructure programmes, in terms of:

- Compensation options and amounts on offer
- Eligibility criteria and exclusion criteria
- Legal requirements and best practices including benchmarking against relevant case law
- Timing of payments
- Numbers of claimants for each element of the scheme and basis for these estimates.

I note from the Noise hearing that the Applicant's noise contour maps appear to deviate significantly from what is seen at other UK airports and that their fleet mix selection is not based on the sector of the market in which the Applicant seeks to operate. This latter point can be confirmed via the audio recording of the Need & Operations hearing.

Noise contour maps form the basis for compensation. If the DCO is awarded and the noise contour maps are subsequently found to be inaccurate it is my understanding that this will need to be taken up through the courts. It is imperative therefore that the Applicant be instructed to reassess their compensation related budget in line with corrections to fleet mix and noise contour maps and the numbers of individuals and households that will be impacted by the proposed scheme.

Kent County Council’s position on night flights as relate to Gatwick Airport (please see attachments provided). Correspondence with Paul Carter, Leader Kent County Council

From: Paul.Carter@kent.gov.uk
Subject: RE: KCC & request for help: Manson night flights
Date: [redacted]
To: [redacted]

Dear Ms Rooke

I am emailing on behalf of Paul Carter, Leader of Kent County Council, to acknowledge and thank you for your below email. I can confirm that your email has been passed to the Leader for his attention and a response will be sent in due course.

Kind regards

Ang

Angela Evans | Secretary to the Leader of the Council
Room 1.75, Sessions House, County Hall, Maidstone, Kent ME14 1XQ | Internal: 416069 | External: 03000 416069 | www.kent.gov.uk

From: Georgina Rooke [redacted]
Sent: 25 March 2019 21:31
To: Carter, Paul - LEADER <Paul.Carter@kent.gov.uk>
Subject: KCC & request for help: Manson night flights

Dear Counsellor Carter,

Please forgive the direct approach however as a resident of Ramsgate concerned by the current proposals to reopen Manston Airport, I have been heartened by your 2015 Position Statement, “Manston Airport under private ownership: The story to date and future prospects” (attached). This document strikes me as setting out a balanced view of Manston’s past and future whilst recognising the considerable investment on the part of KCC to attempt to support previous operators, as well as the challenges posed by a start-up company seeking to reopen it.

I would also like to pay tribute to the proactive way in which your team has stood up for the interests of West Kent residents when Her Majesty’s Government was formulating it’s preferred approach to address passenger capacity constraints facing London Airports. The position on night flights to/from Gatwick is particularly reassuring.

I write to request a similarly robust position in relation to Manston, currently undergoing examination as a Nationally Strategic Infrastructure Project. Whilst KCC is unquestionably responsive to the demands of the current process and clearly promoting adoption of best practice, it would be heartening to see the Council take a similarly forceful position on the impact this project will have on residents in East Kent; the likely viability of the project; and a clear statement on night flights.

Whilst I appreciate that the numbers of night flights at Gatwick amount to 40-50 per night, versus 8 we are told at Manston, Ramsgate residents are between 1.5km - 3km from the runway. Where I live, cargo planes are estimated to fly just 200m from my roof. I am one of many to have bought my home after Manston closed in 2014, and I find the prospect of this situation extremely alarming. It is made worse by the unreliable noise contour maps presented by the Applicant and the consequential implications for compensation.

KCC's LIR makes reference to airspace design in partnership with local residents (see p5 of the attached document, filename starting TR020002). I am concerned that the options available in this regard will be severely restricted as compared to such a remedy suggested for West Kent residents in relation to Gatwick. This is due to our very close proximity to Manston restricting such options.

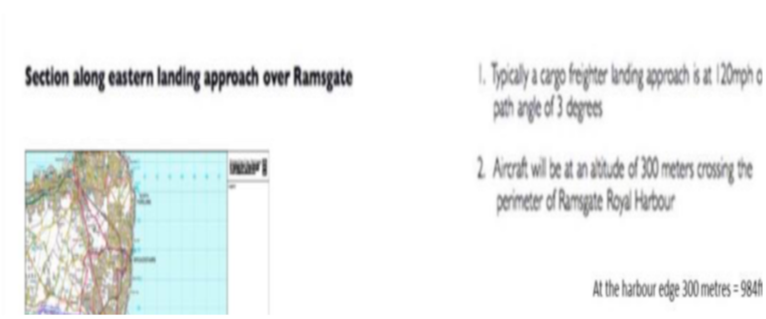
I am also concerned that reference made to the World Health Organisation Environmental Noise Guidelines and the request to adhere to these guidelines if a DCO is approved was somewhat lost in the KCC document and that the relevant section of the WHO document was not clearly cited. Indeed, this reference has been redacted by the Examining Authority making it even less visible to readers of KCC's LIR.

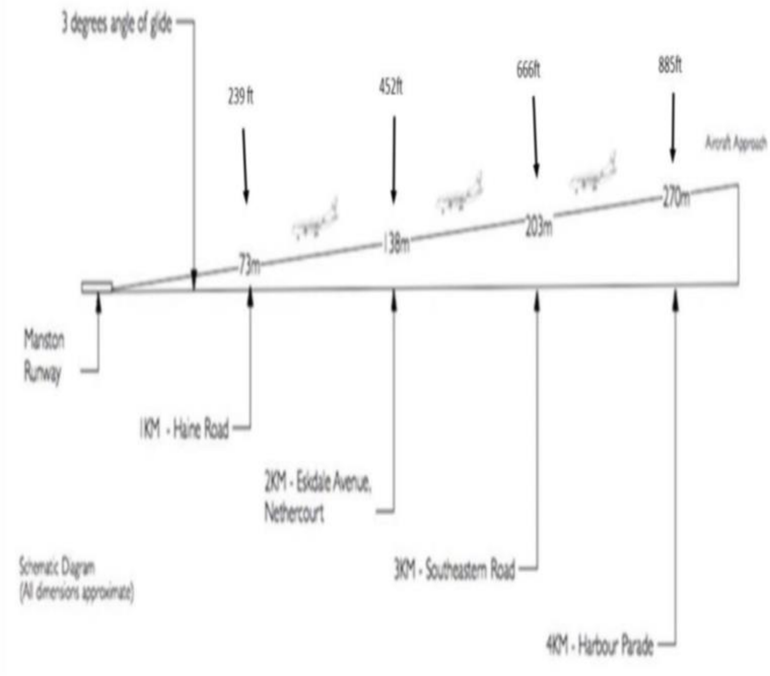
Lastly, I imagine I speak for many of us currently giving up our time to research and participate in this process when I say that a stronger presence from KCC would be very much welcomed in view of the overtly biased support of local MPs. The individuals in question insist that they were elected on a Manston ticket and as far as we know Mr Gale, for example, has not engaged directly with the current legal owner to understand how their plans for the site could benefit the local community. Many of us feel un-represented by local public servants here - and specifically the Conservative Party - in our attempt to protect the respect for our homes, to which we are entitled. To have the clear support from Kent County Council would help redress this imbalance and a mounting feeling that East Kent is of lesser importance to other parts of the County.

Lastly, I should mention that in the interests of transparency I intend to share this email and attachments with the Examining Authority as part of my Deadline 5 submission, because I believe KCC's position on Manston can be better understood within the wider context of KCC's position on Gatwick.

I would welcome your confirmation of receipt of this mail and ongoing support that you and your team can provide.

Kind regards,
Georgina Rooke
[redacted]




3 degrees angle of glide
239 ft
452ft
666ft
885ft
Aircraft Approach
73m
138m
203m
270m
Manston Runway
1KM - Haine Road
2KM - Eskdale Avenue, Nethercourt
3KM - Southeastern Road
4KM - Harbour Parade
Schematic Diagram
(All dimensions approximate)

CONSEIL DE L'EUROPE

COUNCIL OF EUROPE

COUR EUROPÉENNE DES DROITS DE L'HOMME
EUROPEAN COURT OF HUMAN RIGHTS

CASE OF HATTON AND OTHERS v. THE UNITED KINGDOM

(Application no. 36022/97)

GRAND CHAMBER

JUDGMENT

STRASBOURG

8 July 2003

In the case of Hatton and Others v. the United Kingdom,

The European Court of Human Rights, sitting as a Grand Chamber composed of the following judges:

Mr L. WILDHABER, *President*,
Mr J.-P. COSTA,
Mr G. RESS,
Mr G. BONELLO,
Mrs E. PALM,
Mr I. CABRAL BARRETO,
Mr R. TÜRMEN,
Mrs V. STRÁŽNICKÁ,
Mr V. BUTKEVYCH,
Mr B. ZUPANČIČ,
Mrs N. VAJIĆ,
Mrs S. BOTOUCHAROVA,
Mr A. KOVLER,
Mr V. ZAGREBELSKY,
Mrs E. STEINER,
Mr S. PAVLOVSCHI,
Sir Brian KERR, ad hoc *judge*,

and also of Mr P.J. MAHONEY, *Registrar*,

Having deliberated in private on 13 November 2002 and 21 May 2003,

Delivers the following judgment, which was adopted on the last-mentioned date:

PROCEDURE

1. The case originated in an application (no. 36022/97) against the United Kingdom of Great Britain and Northern Ireland lodged on 6 May 1997 with the European Commission of Human Rights ("the Commission") under former Article 25 of the Convention for the Protection of Human Rights and Fundamental Freedoms ("the Convention") by eight United Kingdom nationals, Ms Ruth Hatton, Mr Peter Thake, Mr John Hartley, Ms Philippa Edmunds, Mr John Cavalla, Mr Jeffray Thomas, Mr Richard Bird and Mr Tony Anderson ("the applicants"). The applicants are all members of the Heathrow Association for the Control of Aircraft Noise (HACAN, now HACAN-ClearSkies), which itself is a member of the Heathrow Airport Consultative Committee**.**

2. The applicants were represented by Mr R. Buxton, a lawyer practising in Cambridge. The United Kingdom Government ("the Government") were represented by their Agent, Mr H. Llewellyn, of the Foreign and Commonwealth Office.

3. The applicants alleged that government policy on night flights at Heathrow Airport gave rise to a violation of their rights under Article 8 of the Convention and that they were denied an effective domestic remedy for this complaint, contrary to Article 13 of the Convention.

4. The application was transmitted to the Court on 1 November 1998, when Protocol No. 11 to the Convention came into force (Article 5 § 2 of Protocol No. 11).

5. The application was allocated to the Third Section of the Court (Rule 52 § 1 of the Rules of Court). On 16 May 2000, following a hearing on admissibility and the merits (Rule 54 § 4, former version), it was declared admissible by a Chamber of that Section, composed of Mr J. P. Costa, President, Mr L. Loucaides, Mr P. Kūris, Mrs F. Tulkens, Mr K. Jungwiert, Mrs H.S. Greve, judges, Sir Brian Kerr, *ad hoc* judge, and Mrs S. Dollé, Section Registrar.

6. On 2 October 2001 the Chamber delivered its judgment in which it held, by five votes to two, that there had been a violation of Article 8 of the Convention and, by six votes to one, that there had been a violation of Article 13. The Chamber also decided, by six votes to one, to award compensation for non-pecuniary damage of 4,000 pounds sterling (GBP) to each applicant, and a global sum of GBP 70,000 in respect of legal costs and expenses. The separate opinions of Mr Costa, Mrs Greve and Sir Brian Kerr were annexed to the judgment.

7. On 19 December 2001 the Government requested, in accordance with Article 43 of the Convention and Rule 73, that the case be referred to the Grand Chamber. A panel of the Grand Chamber accepted this request on 27 March 2002.

8. The composition of the Grand Chamber was determined according to the provisions of Article 27 §§ 2 and 3 of the Convention and Rule 24. Mr C.L. Rozakis and Mr P. Lorenzen, who were unable to take part in the final deliberations, were replaced by Mrs E. Steiner and Mr I. Cabral Barreto (Rule 24 § 3).

9. The applicants and the Government each filed written observations on the merits. In addition, third-party comments were received from Friends of the Earth and from British Airways (Article 36 § 2 of the Convention and Rule 61 § 3 of the Rules of Court).

10. A hearing took place in public in the Human Rights Building, Strasbourg, on 13 November 2002 (Rule 59 § 2).

There appeared before the Court:

(a) *for the Government*
Mr H. LLEWELLYN, Foreign and Commonwealth Office, *Agent*,
Lord GOLDSMITH QC, Attorney General,
Mr P. HAVERS QC,
Mr J. EADIE, *Counsel*,
Mr G. GALLIFORD,
Mr P. REARDON,
Mr G. PENDLEBURY,
Ms M. CROKER, *Advisers*;

(b) *for the applicants*
Mr D. ANDERSON QC,
Ms H. MOUNTFIELD, *Counsel*,
Mr R. BUXTON,
Ms S. RING, *Solicitors*,
Mr C. STANBURY,
Mr M. SHENFIELD, *Advisers*.

The Court heard addresses by Mr Anderson and Lord Goldsmith.

THE FACTS

I. THE CIRCUMSTANCES OF THE CASE

A. The degree of disturbance caused to each applicant by night flights

11. Ruth Hatton was born in 1963. Between 1991 and 1997 she lived in East Sheen with her husband and two children. According to information supplied by the Government, her house was 11.7 km from the end of the nearest runway at Heathrow and fell within a daytime noise contour where the level of disturbance from aircraft noise was between 57 and 60 dBa Leq. According to the Government, dBA Leq measure the average degree of community annoyance from aircraft noise over a sixteen-hour daytime period and studies have shown that in areas where the daytime noise exposure is below 57 dBA Leq there is no significant community annoyance. The Government state that a daytime noise contour of 57 dBA Leq represents a low level of annoyance; 63 dBA Leq represent a

moderate level of annoyance; 69 dBA Leq correspond to a high level of annoyance; and 72 dBA Leq represent a very high level of annoyance.

12. According to Ms Hatton, in 1993 the level of night noise increased and she began to find noise levels to be "intolerable" at night. She believed that the noise was greater when aircraft were landing at Heathrow from the east. When this happened, Ms Hatton was unable to sleep without ear plugs and her children were frequently woken up before 6 a.m., and sometimes before 5 a.m. If Ms Hatton did not wear ear plugs, she would be woken by aircraft activity at around 4 a.m. She was sometimes able to go back to sleep, but found it impossible to go back to sleep once the "early morning bombardment" started which, in the winter of 1996/1997, was between 5 a.m. and 5.30 a.m. When she was woken in this manner, Ms Hatton tended to suffer from a headache for the rest of the day. When aircraft were landing from the west the noise levels were lower, and Ms Hatton's children slept much better, generally not waking up until after 6.30 a.m. In the winter of 1993/1994, Ms Hatton became so run down and depressed by her broken sleep pattern that her doctor prescribed anti-depressants. In October 1997, she moved with her family to Kingston-upon-Thames in order to get away from the aircraft noise at night.

13. Peter Thake was born in 1965. From 1990 until 1998, he lived in Hounslow with his partner. His home in Hounslow was situated 4.4 km from Heathrow Airport and slightly to the north of the southern flight path, within a daytime noise contour of between 63 and 66 dBA Leq, according to the Government.

14. Mr Thake claims that in about 1993 the level of disturbance at night from aircraft noise increased notably and he began to be woken or kept awake at night by aircraft noise. Mr Thake found it particularly difficult to sleep in warmer weather, when open windows increased the disturbance from aircraft noise, and closed windows made it too hot to sleep, and he found it hard to go back to sleep after being woken by aircraft noise early in the morning. He was sometimes kept awake by aeroplanes flying until midnight or 1 a.m. and then woken between 4 a.m. and 5 a.m. Mr Thake was also sometimes woken by aeroplanes flying at odd hours in the middle of the night, for example when diverted from another airport. In 1997, Mr Thake became aware that he could complain to the Heathrow Noise Line about aircraft noise if he made a note of the time of the flight. By 30 April 1997, Mr Thake had been sufficiently disturbed to note the time of a flight, and made a complaint to the Heathrow Noise Line on nineteen occasions. He remained in Hounslow until February 1998 because his family, friends and place of work were in the Heathrow area, but moved to Winchester, in Hampshire, when a suitable job opportunity arose, even though it meant leaving his family and friends, in order to escape from the aircraft noise, which was "driving [him] barmy".

15. John Hartley was born in 1948 and has lived with his wife at his present address in Richmond since 1989. According to the information provided by the Government, Mr Hartley's house is 9.4 km from the end of the nearest Heathrow runway and, situated almost directly under the southern approach to the airport, within a daytime noise contour area of between 60 and 63 dBA Leq. The windows of the house are double-glazed.

16. From 1993, Mr Hartley claims to have noticed a “huge” increase in the disturbance caused by flights between 6 a.m. and 6.30 a.m. (or 8 a.m. on Sundays). He states that the British Airports Authority did not operate a practice of alternation (using only one runway for landings for half the day, and then switching landings to the other runway) during this period as it did during the day, and the airport regularly had aircraft landing from the east on both runways. When the wind was blowing from the west and aeroplanes were landing from the east, which was about 70% of the time, aircraft noise would continue until about midnight, so that Mr Hartley was unable to go to sleep earlier than then. He would find it impossible to sleep after 6 a.m. on any day of the week, and was usually disturbed by aircraft noise at about 5 a.m., after which he found he could not go back to sleep. When the aeroplanes were landing from the west, Mr Hartley was able to sleep.

17. Philippa Edmunds was born in 1954 and lives with her husband and two children in East Twickenham. She has lived at her present address since 1992. According to information supplied by the Government, Ms Edmund's house is 8.5 km from the end of the nearest Heathrow runway and approximately 1 km from the flight path, within a daytime noise contour area of under 57 dBA Leq.

18. The applicant claims that before 1993 she was often woken by aircraft noise at around 6 a.m. From 1993, she tended to be woken at around 4 a.m. In 1996, Ms Edmunds and her husband installed double-glazing in their bedroom to try to reduce the noise. Although the double-glazing reduced the noise, Ms Edmunds continued to be woken by aircraft. She suffered from ear infections in 1996 and 1997 as a result of wearing ear plugs at night and, although she was advised by a doctor to stop using them, she continued to do so in order to be able to sleep. Ms Edmunds was also concerned about the possible long-term effects of using ear plugs, including an increased risk of tinnitus. Ms Edmunds's children both suffered from disturbance by aircraft noise.

19. John Cavalla was born in 1925. From 1970 to 1996 he lived with his wife in Isleworth, directly under the flight path of the northern runway at Heathrow Airport. According to information supplied by the Government, the applicant's house was 6.3 km from the end of the nearest Heathrow runway, within a daytime noise contour of between 63 and 66 dBA Leq.

20. The applicant claims that in the early 1990s the noise climate deteriorated markedly, partly because of a significant increase in traffic, but mainly as a result of aircraft noise in the early morning. Mr Cavalla

considers that air traffic increased dramatically between 6 a.m. and 7 a.m. as a result of the shortening of the night quota period. He found that, once woken by an aircraft arriving at Heathrow Airport in the early morning, he was unable to go back to sleep.

21. In 1996, Mr Cavalla and his wife moved to Sunbury in order to get away from the aircraft noise. According to the Government, the new house is 9.5 km from Heathrow, within a daytime noise contour area of under 57 dBA Leq. After moving house, Mr Cavalla did not live under the approach tracks for landing aircraft, and aircraft used the departure route passing over his new home only very rarely at night. Consequently, he was only very rarely exposed to any night-time aircraft noise following his move.

22. Jeffray Thomas was born in 1928 and lives in Kew with his wife and two sons, and the wife and son of one of those sons. The family have lived at their present address since 1975, in a house lying between the north and south Heathrow flight paths. According to the Government, it is 10.7 km from Heathrow, within a noise contour area of 57 to 60 dBA Leq. Aircraft pass overhead on seven or eight days out of every ten when the prevailing wind is from the west.

23. Mr Thomas claims to have noticed a sudden increase in night disturbance in 1993. He complains of being woken at 4.30 a.m., when three or four large aircraft tended to arrive within minutes of each other. Once he was awake, one large aeroplane arriving every half hour was sufficient to keep him awake until 6 a.m. or 6.30 a.m., when the aeroplanes started arriving at frequencies of up to one a minute until about 11 p.m.

24. Richard Bird was born in 1933 and lived in Windsor for thirty years until he retired in December 1998. His house in Windsor was directly under the westerly flight path to Heathrow Airport. According to the Government, it was 11.5 km from Heathrow, within a daytime noise contour area of 57 to 60 dBA Leq.

25. The applicant claims that in recent years, and particularly from 1993, he and his wife suffered from intrusive aircraft noise at night. Although Mr Bird observed that both take-offs and landings continued later and later into the evenings, the main problem was caused by the noise of early morning landings. He stated that on very many occasions he was woken at 4.30 a.m. or 5 a.m. by incoming aircraft, and was then unable to get back to sleep, and felt extremely tired later in the day. Mr Bird retired in December 1998 and moved with his wife to Wokingham, in Surrey, specifically to get away from the aircraft noise which was “really getting on [his] nerves”.

26. Tony Anderson was born in 1932 and has lived since 1963 in Touchen End, under the approach to runway 09L at Heathrow Airport and, according to the Government, 17.3 km from the end of the nearest runway, within a daytime noise contour area of under 57 dBA Leq.

According to the applicant, by 1994 he began to find that his sleep was being disturbed by aircraft noise at night, and that he was being woken at 4.15 a.m. or even earlier by aircraft coming in from the west to land at Heathrow Airport.

27. The dBA Leq noise contour figures supplied by the Government and referred to above measure levels of annoyance caused by noise during the course of an average summer day. The Government state that it is not possible to map equivalent contours for night noise disturbance, because there is no widely accepted scale or standard with which to measure night-time annoyance caused by aircraft noise. However, the Government claim that the maximum "average sound exposure" levels, in decibels (dBA), suffered by each applicant as a result of the seven different types of aircraft arriving at Heathrow before 6 a.m. each morning is as follows: Ms Hatton – 88 dBA; Mr Thake – 88.8 dBA; Mr Hartley – 89.9 dBA; Ms Edmunds – 83.4 dBA; Mr Cavalla (at his previous address) – 94.4 dBA; Mr Thomas – 88.7 dBA; Mr Bird – 87.8 dBA; and Mr Anderson – 84.1 dBA.

The Government further claim that the average "peak noise event" levels, that is the maximum noise caused by a single aircraft movement, suffered by each applicant at night are as follows: Mrs Hatton – 76.3 dBA; Mr Thake – 77.1 dBA; Mr Hartley – 78.9 dBA; Ms Edmunds – 70 dBA; Mr Cavalla (at his previous address) – 85 dBA; Mr Thomas – 77.2 dBA; Mr Bird – 76 dBA; Mr Anderson – 71.1 dBA.

The Government claim that research commissioned before the 1993 review of night restrictions indicated that average outdoor sound exposure levels of below 90 dBA, equivalent to peak noise event levels of approximately 80 dBA, were unlikely to cause any measurable increase in overall rates of sleep disturbance experienced during normal sleep. The applicants, however, refer to World Health Organisation "Guidelines for Community Noise", which gave a guideline value for avoiding sleep disturbance at night of a single noise event of 60 dBA[1].

B. The night-time regulatory regime for Heathrow Airport

28. Heathrow Airport is the busiest airport in Europe, and the busiest international airport in the world. It is used by over 90 airlines, serving over 180 destinations world-wide. It is the United Kingdom's leading port in terms of visible trade.

1. The Government note that these guidelines were promulgated in 1999, and that they represent a target at which sleep will not be disturbed, rather than an international standard.

29. Restrictions on night flights at Heathrow Airport were introduced in 1962 and have been reviewed periodically, most recently in 1988, 1993 and 1998.

30. Between 1978 and 1987, a number of reports into aircraft noise and sleep disturbance were published by or on behalf of the Civil Aviation Authority.

31. A Consultation Paper was published by the United Kingdom government in November 1987 in the context of a review of the night restrictions policy at Heathrow. The Consultation Paper stated that research into the relationship between aircraft noise and sleep suggested that the number of movements at night could be increased by perhaps 25% without worsening disturbance, provided levels of dBA Leq were not increased.

32. It indicated that there were two reasons for not considering a ban on night flights: firstly, that a ban on night flights would deny airlines the ability to plan some scheduled flights in the night period, and to cope with disruptions and delays; secondly, that a ban on night flights would damage the status of Heathrow Airport as a twenty-four-hour international airport (with implications for safety and maintenance and the needs of passengers) and its competitive position in relation to a number of other European airports.

33. From 1988 to 1993, night flying was regulated solely by means of a limitation on the number of take-offs and landings permitted at night. The hours of restriction were as follows:

Summer	11.30 p.m. to 6 a.m. weekdays,
	11.30 p.m. to 6 a.m. Sunday landings,
	11.30 p.m. to 8 a.m. Sunday take-offs;
Winter	11.30 p.m. to 6.30 a.m. weekdays,
	11.30 p.m. to 8 a.m. Sunday take-offs and landings.

34. In July 1990, the Department of Transport commenced an internal review of the restrictions on night flights. A new classification of aircraft and the development of a quota count system were the major focus of the review. As part of the review, the Department of Transport asked the Civil Aviation Authority to undertake further objective study of aircraft noise and sleep disturbance. The objectives of the review included "to continue to protect local communities from excessive aircraft noise at night" and "to ensure that the competitive influences affecting UK airports and airlines and the wider employment and economic implications are taken into account".

35. The fieldwork for the study was carried out during the summer of 1991. Measurements of disturbance were obtained from 400 subjects living in the vicinity of Heathrow, Gatwick, Stansted and Manchester Airports. The findings were published in December 1992 as the "Report of a field study of aircraft noise and sleep disturbance" ("the 1992 sleep study"). It found that, once asleep, very few people living near airports were at risk of

any substantial sleep disturbance due to aircraft noise and that, compared with the overall average of about eighteen nightly awakenings without any aircraft noise, even large numbers of noisy night-time aircraft movements would cause very little increase in the average person's nightly awakenings. It concluded that the results of the field study provided no evidence to suggest that aircraft noise was likely to cause harmful after-effects. It also emphasised, however, that its conclusions were based on average effects, and that some of the subjects of the study (2 to 3%) were over 60% more sensitive than average.

36. In January 1993, the government published a Consultation Paper regarding a proposed new scheme for regulating night flights at the three main airports serving London: Heathrow, Gatwick and Stansted. The Consultation Paper set up four objectives of the review being undertaken (so far as Heathrow was concerned): to revise and update the existing arrangements; to introduce a common night flights regime for the three airports; to continue to protect local communities from excessive aircraft noise levels at night; and to ensure that competitive influences and the wider employment and economic implications were taken into account. In a section entitled “Concerns of local people”, the Consultation Paper referred to arguments that night flights should be further restricted or banned altogether. In the authors' view, the proposals struck a fair balance between the different interests and did “protect local people from excessive aircraft noise at night”. In considering the demand for night flights, the Consultation Paper made reference to the fact that, if restrictions on night flights were imposed in the United Kingdom, certain flights would not be as convenient or their costs would be higher than those that competitors abroad could offer, and that passengers would choose alternatives that better suited their requirements.

37. It also stated that various foreign operators were based at airports with no night restrictions, which meant that they could keep prices down by achieving a high utilisation of aircraft, and that this was a crucial factor in attracting business in what was a highly competitive and price-sensitive market.

38. Further, the Consultation Paper stated that both regular and charter airlines believed that their operations could be substantially improved by being allowed more movements during the night period, especially landings.

It also indicated that charter companies required the ability to operate in the night period, as they operated in a highly competitive, price-sensitive market and needed to contain costs as much as possible. The commercial viability of their business depended on high utilisation of their aircraft, which typically required three rotations a day to nearer destinations, and this could only be fitted in by using movements at night.

39. Finally, as regards night flights, the Consultation Paper referred to the continuing demand for some all-cargo flights at night carrying mail and other time-sensitive freight such as newspapers and perishable goods, and pointed to the fact that all-cargo movements were banned, whether arriving or departing, for much of the day at Heathrow Airport.

40. The Consultation Paper referred to the 1992 sleep study, noting that it had found that the number of disturbances caused by aircraft noise was so small that it had a negligible effect on overall normal disturbance rates, and that disturbance rates from all causes were not at a level likely to affect people's health or well-being.

41. The Consultation Paper further stated that, in keeping with the undertaking given in 1988 not to allow a worsening of noise at night, and ideally to reduce it, it was proposed that the quota for the next five years based on the new system should be set at a level such as to keep overall noise levels below those in 1988.

42. A considerable number of responses to the Consultation Paper were received from trade and industry associations with an interest in air travel (including the International Air Transport Association (IATA), the Confederation of British Industry and the London and Thames Valley Chambers of Commerce) and from airlines, all of which emphasised the economic importance of night flights. Detailed information and figures were provided by the associations and the airlines to support their responses.

43. On 6 July 1993 the Secretary of State for Transport announced his intention to introduce, with effect from October 1993, a quota system of night flying restrictions, the stated aim of which was to reduce noise at the three main London airports, which included Heathrow ("the 1993 Scheme").

44. The 1993 Scheme introduced a noise quota scheme for the night quota period. Under the noise quota scheme each aircraft type was assigned a "quota count" between 0.5 QC (for the quietest) and 16 QC (for the noisiest). Each airport was then allotted a certain number of quota points, and aircraft movements had to be kept within the permitted points total. The effect of this was that, under the 1993 Scheme, rather than a maximum number of individual aircraft movements being specified, aircraft operators could choose within the noise quota whether to operate a greater number of quieter aeroplanes or a lesser number of noisier aeroplanes. The system was designed, according to the 1993 Consultation Paper, to encourage the use of quieter aircraft by making noisier types use more of the quota for each movement.

45. The 1993 Scheme defined "night" as the period between 11 p.m. and 7 a.m., and further defined a "night quota period" from 11.30 p.m. to 6 a.m., seven days a week, throughout the year, when the controls were strict. During the night, operators were not permitted to schedule the noisier types of aircraft to take off (aircraft with a quota count of 8 QC or 16 QC) or to

land (aircraft with a quota count of 16 QC). During the night quota period, aircraft movements were restricted by a movements limit and a noise quota, which were set for each season (summer and winter).

46. The 1993 Consultation Paper had proposed a rating of 0 QC for the quietest aircraft. This would have allowed an unlimited number of these aircraft to fly at night, and the government took account of objections to this proposal in deciding to rate the quietest aircraft at 0.5 QC. Otherwise, the 1993 Scheme was broadly in accordance with the proposals set out in the 1993 Consultation Paper.

47. The local authorities for the areas around the three main London airports sought judicial review of the Secretary of State's decision to introduce the 1993 Scheme, making four consecutive applications for judicial review and appealing twice to the Court of Appeal (see paragraphs 80-83 below). As a result of the various judgments delivered by the High Court and Court of Appeal, the government consulted on revised proposals in October and November 1993; commissioned a study by ANMAC (the Aircraft Noise Monitoring Advisory Committee of the Department of the Environment, Transport and the Regions (DETR) formerly the Department of Transport) in May 1994 into ground noise at night at Heathrow, Gatwick and Stansted Airports; added to the quota count system an overall maximum number of aircraft movements; issued a further Consultation Paper in March 1995 and issued a supplement to the March 1995 Consultation Paper in June 1995.

48. The June 1995 supplement stated that the Secretary of State's policies and the proposals based on them allowed more noise than was experienced from actual aircraft movements in the summer of 1988, and acknowledged that this was contrary to government policy, as expressed in the 1993 Consultation Paper. As part of the 1995 review of the 1993 Scheme, the government reviewed the Civil Aviation Authority reports on aircraft noise and sleep disturbance, including the 1992 sleep study. The DETR prepared a series of papers on night arrival and departure statistics at Heathrow, Gatwick and Stansted Airports, scheduling and curfews in relation to night movements, runway capacity between 6 a.m. and 7 a.m., Heathrow night arrivals for four sample weeks in 1994, and Heathrow night departures for four sample weeks in 1994. The DETR also considered a paper prepared by Heathrow Airport Limited on the implications of a prohibition on night flights between 12 midnight and 5.30 a.m.

49. On 16 August 1995 the Secretary of State for Transport announced that the noise quotas and all other aspects of the night restrictions regime would remain as previously announced. In July 1996, the Court of Appeal confirmed the lawfulness of the 1993 Scheme, as it had been amended (see paragraphs 82-83 below).

50. The movement limits for Heathrow under the 1993 Scheme, introduced as a consequence of the legal challenges in the domestic courts,

were set at 2,550 per winter season from 1994/1995 to 1997/1998, and 3,250 per summer season from 1995 to 1998 (the seasons being deemed to change when the clocks changed from Greenwich Mean Time (GMT) to British Summer Time (BST)). The noise quotas for Heathrow up to the summer of 1998 were set at 5,000 for each winter season and 7,000 for each summer season. Flights involving emergencies were excluded from the restrictions. The number of movements permitted during the night quota period (i.e. from 11.30 p.m. to 6 a.m.) remained at about the same level as between 1988 and 1993. At the same time, the number of movements permitted during the night period (i.e. from 11 p.m. to 7 a.m.) increased under the 1993 Scheme due to the reduction in the length of the night quota period.

51. In September 1995, a trial was initiated at Heathrow Airport of modified procedures for early morning landings (those between 4 a.m. and 6 a.m.). The aim of the trial, which was conducted by National Air Traffic Services Limited on behalf of the DETR, was to help alleviate noise over parts of central London in the early morning. An interim report, entitled "Assessment of revised Heathrow early mornings approach procedures trial", was published in November 1998.

52. In December 1997, a study, commissioned by the DETR and carried out by the National Physical Laboratory gave rise to a report, "Night noise contours: a feasibility study", which was published the same month. The report contained a detailed examination of the causes and consequences of night noise, and identified possible areas of further research. It concluded that there was not enough research evidence to produce "scientifically robust night contours that depict levels of night-time annoyance".

53. In 1998, the government conducted a two-stage consultation exercise on night restrictions at Heathrow, Gatwick and Stansted Airports. In February 1998, a Preliminary Consultation Paper on night restrictions at Heathrow, Gatwick and Stansted was published. The Preliminary Consultation Paper stated that most night movements catered primarily for different needs from those that took place during the daytime, and set out reasons for allowing night flights. These were essentially the same as those given in the 1993 Consultation Paper.

54. In addition, the Preliminary Consultation Paper referred to the fact that air transport was one of the fastest growing sectors of the world economy and contained some of the United Kingdom's most successful firms. Air transport facilitated economic growth, world trade, international investment and tourism, and was of particular importance to the United Kingdom because of its open economy and geographical position. The Consultation Paper went on to say that permitting night flights, albeit subject to restrictions, at major airports in the United Kingdom had contributed to this success.

55. The government set movement limits and noise quotas for winter 1998/99 at the same level as for the previous winter, in order to allow adequate time for consultation.

56. The British Air Transport Association (BATA) commissioned a report from Coopers & Lybrand into the economic costs of maintaining the restrictions on night flights. The report was published in July 1997 and was entitled "The economic costs of night flying restrictions at the London airports". The report concluded that the economic cost of the then current restrictions being maintained during the period 1997/1998 to 2002/2003 was about 850 million pounds sterling (GBP). BATA submitted the report to the government when it responded to the Preliminary Consultation Paper.

57. On 10 September 1998 the Government announced that the movement limits and noise quotas for summer 1999 would be the same as for summer 1998.

58. In November 1998, the government published the second stage Consultation Paper on night restrictions at Heathrow, Gatwick and Stansted. The Consultation Paper stated that it had been the view of successive governments that the policy on night noise should be firmly based on research into the relationship between aircraft noise and interference with sleep and that, in order to preserve the balance between the different interests, this should continue to be the basis for decisions. The Consultation Paper indicated that "interference with sleep" was intended to cover both sleep disturbance (an awakening from sleep, however short) and sleep prevention (a delay in first getting to sleep at night, and awakening and then not being able to get back to sleep in the early morning). The Consultation Paper stated that further research into the effect of aircraft noise on sleep had been commissioned, which would include a review of existing research in the United Kingdom and abroad, and a trial to assess methodology and analytical techniques to determine whether to proceed to a full-scale study of either sleep prevention or total sleep loss.

59. The Consultation Paper repeated the finding of the 1992 sleep study that for noise events in the range of 90-100 dBA SEL (80-95 dBA Lmax), the likelihood of the average person being awakened by an aircraft noise event was about 1 in 75. It acknowledged that the 1 in 75 related to sleep disturbance, and not to sleep prevention, and that while there was a substantial body of research on sleep disturbance, less was known about sleep prevention or total sleep loss.

60. The Consultation Paper stated that the objectives of the current review were, in relation to Heathrow, to strike a balance between the need to protect local communities from excessive aircraft noise levels at night and to provide for air services to operate at night where they were of benefit to the local, regional and national economy; to ensure that the competitive factors affecting United Kingdom airports and airlines and the wider employment and economic implications were taken into account; to take

account of the research into the relationship between aircraft noise and interference with sleep and any health effects; to encourage the use of quieter aircraft at night; and to put in place at Heathrow, for the night quota period (11.30 p.m. to 6 a.m.), arrangements which would bring about further improvements in the night noise climate around the airport over time and update the arrangements as appropriate.

61. The Consultation Paper stated that since the introduction of the 1993 Scheme, there had been an improvement in the noise climate around Heathrow during the night quota period, based on the total of the quota count ratings of aircraft counted against the noise quota, but that there had probably been a deterioration over the full night period between 11 p.m. and 7 a.m. as a result of the growth in traffic between 6 a.m. and 7 a.m.

62. The Consultation Paper found a strong customer preference for overnight long-haul services from the Asia-Pacific region.

63. The Consultation Paper indicated that the government had not attempted to quantify the aviation and economic benefits of night flights in financial terms. This was because of the difficulties in obtaining reliable and impartial data on passenger and economic benefits (some of which were commercially sensitive) and modelling these complex interactions. BATA had submitted a copy of the Coopers & Lybrand July 1997 report with its response to the Preliminary Consultation Paper, and the Consultation Paper noted that the report estimated the value of an additional daily long-haul scheduled night flight at Heathrow to be GBP 20 million to GBP 30 million per year, over half of which was made up of airline profits. The Consultation Paper stated that the financial effects on airlines were understood to derive from estimates made by a leading United Kingdom airline. Other parts of the calculation reflected assumptions about the effects on passengers and knock-on effects on other services, expressed in terms of an assumed percentage of the assumed revenue earned by these services. The Consultation Paper stated that the cost of restricting existing night flights more severely might be different, and that BATA's figures took no account of the wider economic effects which were not captured in the estimated airline and passenger impacts.

64. The Consultation Paper stated that, in formulating its proposals, the government had taken into account both BATA's figures and the fact that it was not possible for the government to test the estimates or the assumptions made by BATA. Any value attached to a “marginal” night flight had to be weighed against the environmental disadvantages. These could not be estimated in financial terms, but it was possible, drawing on the 1992 sleep study, to estimate the number of people likely to be awakened. The Consultation Paper concluded that, in forming its proposals, the government must take into account, on the one hand, the important aviation interests involved and the wider economic considerations. It seemed clear that United Kingdom airlines and airports would stand to lose business, including in the

daytime, if prevented by unduly severe restrictions from offering limited services at night, that users could also suffer, and that the services offered by United Kingdom airports and airlines would diminish, and with them the appeal of London and the United Kingdom more generally. On the other hand, these considerations had to be weighed against the noise disturbance caused by night flights. The proposals made in the Consultation Paper aimed to strike a balance between the different interests and, in the government's view, would protect local people from excessive aircraft noise at night.

65. The main proposals in relation to Heathrow were: not to introduce a ban on night flights, or a curfew period; to retain the seasonal noise quotas and movement limits; to review the QC classifications of individual aircraft and, if this produced significant re-classifications, to reconsider the quota limits; to retain the QC system; to review the QC system before the 2002 summer season (when fleet compositions would have changed following completion of the compulsory phase-out in Europe of “Chapter 2” civil aircraft, with the exception of Concorde, which began in April 1995), in accordance with the policy of encouraging the use of quieter aircraft; to reduce the summer and winter noise quotas; to maintain the night period as 11 p.m. to 7 a.m. and the night quota period as 11.30 p.m. to 6 a.m.; to extend the restrictions on aircraft classified as QC8 on arrival or departure to match those for QC16; and to ban QC4 aircraft from being scheduled to land or take off during the night quota period from the start of the 2002 summer season (that is, after completion of the compulsory Chapter 2 phase-out).

66. The Consultation Paper stated that since the introduction of the 1993 Scheme, headroom had developed in the quotas, reducing the incentive for operators to use quieter aircraft. The reduction in summer and winter noise quotas to nearer the level of current usage was intended as a first step to restoring the incentive. The winter noise quota level under the 1993 Scheme was 5,000 QC points, and the average usage in the last two traffic seasons had been 3,879 QC points. A reduction to 4,000 was proposed. The summer noise quota level had been 7,000 points, and the average usage in the last two seasons was provisionally calculated at 4,472. A reduction to 5,400 was proposed. The new levels would remain in place until the end of the summer 2004 season, subject to the outcome of the QC review.

67. Part 2 of the Consultation Paper invited comments as to whether runway alternation should be introduced at Heathrow at night, and on the preferential use of Heathrow's runways at night.

68. On 10 June 1999 the government announced that the proposals in the November 1998 Consultation Paper would be implemented with effect from 31 October 1999, with limited modifications. With respect to Heathrow, the only modification was that there was to be a smaller reduction in the noise quotas than proposed. The quotas were set at 4,140 QC points for the

winter, and 5,610 QC points for the summer. The effect of this was to set the winter quota at a level below actual usage in winter 1998/99.

69. The 1999 Scheme came into effect on 31 October 1999.

70. On 10 November 1999, a report was published on "The contribution of the aviation industry to the UK economy". The report was prepared by Oxford Economic Forecasting and was sponsored by a number of airlines, airport operators and BATA, as well as the government.

71. On 23 November 1999 the government announced that runway alternation at Heathrow would be extended into the night "at the earliest practicable opportunity", and issued a further Consultation Paper concerning proposals for changes to the preferential use of Heathrow's runways at night.

72. In December 1999, the DETR and National Air Traffic Services Limited published the final report of the ANMAC Technical Working Group on "Noise from Arriving Aircraft". The purpose of the report was to describe objectively the sources of operational noise for arriving aircraft, to consider possible means of noise amelioration, and to make recommendations to the DETR.

73. In March 2000, the Department of Operational Research and Analysis (DORA) published a report, prepared on behalf of the DETR, entitled "Adverse effects of night-time aircraft noise". The report identified a number of issues for possible further research, and was intended to form the background to any future United Kingdom studies of night-time aircraft noise. The report stated that gaps in knowledge had been identified, and indicated that the DETR was considering whether there was a case for a further full-scale study on the adverse effects of night-time aircraft noise, and had decided to commission two further short research studies to investigate the options. These studies were commissioned in the autumn of 1999, before the publication of the DORA report. One is a trial study to assess research methodology. The other is a social survey the aims of which included an exploration of the difference between objectively measured and publicly received disturbance due to aircraft noise at night. Both studies are being conducted by university researchers.

74. A series of noise mitigation and abatement measures is in place at Heathrow Airport, in addition to restrictions on night flights. These include the following: aircraft noise certification to reduce noise at source; the compulsory phasing out of older, noisier jet aircraft; noise preferential routes and minimum climb gradients for aircraft taking off; noise abatement approach procedures (continuous descent and low power/low drag procedures); limitation of air transport movements; noise-related airport charges; noise insulation grant schemes; and compensation for noise nuisance under the Land Compensation Act 1973.

75. The DETR and the management of Heathrow Airport conduct continuous and detailed monitoring of the restrictions on night flights.

Reports are provided each quarter to members of the Heathrow Airport Consultative Committee, on which local government bodies responsible for areas in the vicinity of Heathrow Airport and local residents' associations are represented.

II. RELEVANT DOMESTIC LAW AND PRACTICE

A. The Civil Aviation Act 1982 ("the 1982 Act")

76. Section 76(1) of the 1982 Act provides, in its relevant part:

> "No action shall lie in respect of trespass or in respect of nuisance, by reason only of the flight of an aircraft over any property at a height above the ground which, having regard to wind, weather and all the circumstances of the case, is reasonable, or the ordinary incidents of such flight, so long as the provisions of any Air Navigation Order ... have been duly complied with ..."

77. Air Navigation Orders made under the 1982 Act provide for Orders in Council to be made for the regulation of aviation. Orders in Council have been made to deal with, amongst other matters, engine emissions, noise certification and compensation for noise nuisance.

78. Section 78(3) of the 1982 Act provides, in its relevant part:

> "If the Secretary of State considers it appropriate for the purpose of avoiding, limiting or mitigating the effect of noise and vibration connected with the taking-off or landing of aircraft at a designated aerodrome, to prohibit aircraft from taking off or landing, or limit the number of occasions on which they may take off or land, at the aerodrome during certain periods, he may by a notice published in the prescribed manner do all or any of the following, that is to say –
>
> (a) prohibit aircraft of descriptions specified in the notice from taking off or landing at the aerodrome (otherwise than in an emergency of a description so specified) during periods so specified;
>
> (b) specify the maximum number of occasions on which aircraft of descriptions so specified may be permitted to take off or land at the aerodrome ... during the periods so specified;
>
> ..."

79. Restrictions on night flights at Heathrow Airport are imposed by means of notices published by the Secretary of State under section 78(3) of the 1982 Act.

B. The challenges to the 1993 Scheme

80. The local authorities for the areas around the three main London airports sought judicial review of the Secretary of State's decision to introduce the 1993 Scheme. They made four consecutive applications for judicial review, and appealed twice to the Court of Appeal. The High Court declared that the 1993 Scheme was contrary to the terms of section 78(3)(b) of the 1982 Act, and therefore invalid, because it did not "specify the maximum number of occasions on which aircraft of descriptions so specified may be permitted to take off or land" but, instead, imposed controls by reference to levels of exposure to noise energy (see *R. v. Secretary of State for Transport, ex parte Richmond upon Thames Borough Council and Others* [1994] 1 Weekly Law Reports 74).

81. The Secretary of State decided to retain the quota count system, but with the addition of an overall maximum number of aircraft movements. This decision was held by the High Court to be in accordance with section 78(3)(b) of the 1982 Act. However, the 1993 Consultation Paper was held to have been "materially misleading" in failing to make clear that the implementation of the proposals for Heathrow Airport would permit an increase in noise levels over those experienced in 1988 (see *R. v. Secretary of State for Transport, ex parte Richmond upon Thames Borough Council and Others* [1995] Environmental Law Reports 390).

82. Following the publication of a further Consultation Paper in March 1995, and of a supplement to the March 1995 Consultation Paper in June 1995, the local authorities brought a further application for judicial review. In July 1996, the Court of Appeal decided that the Secretary of State had given adequate reasons and sufficient justification for his conclusion that it was reasonable, on balance, to run the risk of diminishing to some degree local people's ability to sleep at night because of the other countervailing considerations to which he was, in 1993, willing to give greater weight, and that by June 1995 errors in the consultation papers had been corrected and the new policy could not be said to be irrational (see *R. v. Secretary of State for Transport, ex parte Richmond LBC* [1996] 1 Weekly Law Reports 1460).

83. On 12 November 1996 the House of Lords dismissed a petition by the local authorities for leave to appeal against the decision of the Court of Appeal.

THE LAW

I. ALLEGED VIOLATION OF ARTICLE 8 OF THE CONVENTION

84. The applicants complained that the government policy on night flights at Heathrow introduced in 1993 violated their rights under Article 8 of the Convention, which provides:

> “1. Everyone has the right to respect for his private and family life, his home and his correspondence.
>
> 2. There shall be no interference by a public authority with the exercise of this right except such as is in accordance with the law and is necessary in a democratic society in the interests of national security, public safety or the economic well-being of the country, for the prevention of disorder or crime, for the protection of health or morals, or for the protection of the rights and freedoms of others.”

The Government denied that there had been any violation of the Convention in this case.

A. The general principles

1. The Chamber's judgment

85. In its judgment of 2 October 2001, the Chamber held that because Heathrow Airport and the aircraft which used it were not owned, controlled or operated by the government or its agents, the United Kingdom could not be said to have “interfered” with the applicants' private or family lives. Instead, the Chamber analysed the applicants' complaints in terms of a positive duty on the State to take reasonable and appropriate measures to secure the applicants' rights under Article 8 § 1 (see paragraph 95 of the Chamber's judgment).

86. The Chamber further held that, whatever analytical approach was adopted, regard must be had to the fair balance that had to be struck between the competing interests of the individual and the community as a whole. In both contexts, the State enjoyed a certain margin of appreciation in determining the steps to be taken to ensure compliance with the Convention (see paragraph 96 of the Chamber's judgment). However, the Chamber underlined that in striking the required balance States must have regard to the whole range of material considerations. Further, in the particularly sensitive field of environmental protection, mere reference to the economic well-being of the country was not sufficient to outweigh the

rights of others. The Chamber considered that States were required to minimise, as far as possible, interference with Article 8 rights, by trying to find alternative solutions and by generally seeking to achieve their aims in the least onerous way as regards human rights. In order to do that, a proper and complete investigation and study, with the aim of finding the best possible solution which would, in reality, strike the right balance, should precede the relevant project (see paragraph 97 of the Chamber's judgment).

2. *The parties' submissions*

(a) The Government

87. In their letter requesting that the case be referred to the Grand Chamber, and in their written and oral observations to the Grand Chamber, the Government strongly objected to the “minimum interference” approach outlined by the Chamber in paragraph 97 of its judgment.

The Government argued that this test in the context of the present type of case was at odds with a consistent line of Convention jurisprudence and was unwarranted in principle. They submitted that the test reduced to vanishing-point the margin of appreciation afforded to States in an area involving difficult and complex balancing of a variety of competing interests and factors.

88. Not merely was there clear authority in favour of a wide margin, it was appropriate and right in principle that the State should be allowed such a margin in a context such as the present, since it involved the balancing of a number of competing rights and interests, the importance and sensitivity of some of which might be difficult accurately to evaluate. There was no single correct policy to be applied as regards the regulation of night flights; States could and did adopt a variety of different approaches. The Government reasoned that the present context was similar to the field of planning policy, where the Court had consistently recognised that by reason of their direct and continuous contact with the vital forces of their countries and because of the range of discretionary issues involved, the national authorities were in principle better placed than an international court to evaluate local conditions and needs.

89. They accepted that inherent in the striking of a fair balance was a need to be sufficiently informed in relation to the relevant issues, in order to avoid making or appearing to make an arbitrary decision. However, the decision-making process was primarily for the national authorities, in this case, the government, subject to judicial review by the domestic courts. The European Court's powers in this context were supervisory: in the absence of any indication of an arbitrary or clearly inadequate investigation, a detailed and minute critique of the information which the government should take into account was neither necessary nor appropriate.

(b) The applicants

90. The applicants argued that it was well established from previous case-law that aircraft noise was capable of infringing the Article 8 rights of those sufficiently affected by it and that national authorities owed a positive duty to take steps to ensure the effective protection of these rights. Relying on earlier environmental cases and also child-care and other cases under Article 8, they submitted that the duty could be breached in circumstances where, having regard to the margin of appreciation, the Court considered that the State had struck the wrong substantive balance between the interest it pursued and the individual's effective enjoyment of the Article 8 right, or where there had been a procedural failing, such as the failure to disclose information to an individual affected by environmental nuisance or a failure to base a decision-making process on the relevant considerations or to give relevant and sufficient reasons for an interference with a fundamental right.

91. The applicants accepted that any informed assessment of whether an interference with Article 8 rights was "necessary in a democratic society" would be accorded a margin of appreciation, the width of that margin depending on the context. However, they submitted that in the present case the margin should be narrow, because deprivation of sleep by exposure to excessive noise, like the infliction of inhuman or degrading treatment, was a matter which could and should be judged by similar standards in similar Contracting States.

92. Moreover, where a case – such as the present – could be decided on the basis of a procedural breach, namely the government's failure properly to assemble the evidence necessary for the decision-making process, the doctrine of the margin of appreciation had no role to play, since the international judge was well placed to assess the adequacy of the procedural safeguards applied by the State.

93. For the applicants, the approach of the Chamber – that the violation of Article 8 was based on the government's failure to assemble the evidence that would have been necessary for the decision to be made on the basis of the relevant considerations – was but one way of dealing with the case. A violation of Article 8 could also be established on the basis that the necessary steps to ensure protection of Article 8 rights were not taken, that "relevant and sufficient reasons" had not been given for the interference, or that the substantive balance of interests had not been properly struck.

3. The third parties

94. Friends of the Earth submitted that the Chamber's judgment in the present case was consistent with developments in national and international law concerning the relationship between human rights and the environment. In particular, it was consistent with requirements under general international law requiring decision-makers to satisfy themselves by means of proper,

complete, and prior investigation as to the factors which should be taken into account in order to achieve an appropriate balance between individual rights and the State's economic interests.

95. British Airways did not comment on the general principles to be applied by the Court.

4. The Court's assessment

96. Article 8 protects the individual's right to respect for his or her private and family life, home and correspondence. There is no explicit right in the Convention to a clean and quiet environment, but where an individual is directly and seriously affected by noise or other pollution, an issue may arise under Article 8. Thus, in *Powell and Rayner v. the United Kingdom* (judgment of 21 February 1990, Series A no. 172, p. 18, § 40), where the applicants had complained about disturbance from daytime aircraft noise, the Court held that Article 8 was relevant, since "the quality of [each] applicant's private life and the scope for enjoying the amenities of his home [had] been adversely affected by the noise generated by aircraft using Heathrow Airport". Similarly, in *López Ostra v. Spain* (judgment of 9 December 1994, Series A no. 303-C, pp. 54-55, § 51) the Court held that Article 8 could include a right to protection from severe environmental pollution, since such a problem might "affect individuals' well-being and prevent them from enjoying their homes in such a way as to affect their private and family life adversely, without, however, seriously endangering their health". In *Guerra and Others v. Italy* (judgment of 19 February 1998, *Reports of Judgments and Decisions* 1998-I), which, like *López Ostra*, concerned environmental pollution, the Court observed that "[the] direct effect of the toxic emissions on the applicants' right to respect for their private and family life means that Article 8 is applicable" (p. 227, § 57).

97. At the same time, the Court reiterates the fundamentally subsidiary role of the Convention. The national authorities have direct democratic legitimation and are, as the Court has held on many occasions, in principle better placed than an international court to evaluate local needs and conditions (see, for example, *Handyside v. the United Kingdom*, judgment of 7 December 1976, Series A no. 24, p. 22, § 48). In matters of general policy, on which opinions within a democratic society may reasonably differ widely, the role of the domestic policy-maker should be given special weight (see *James and Others v. the United Kingdom*, judgment of 21 February 1986, Series A no. 98, p. 32, § 46, where the Court found it natural that the margin of appreciation "available to the legislature in implementing social and economic policies should be a wide one").

98. Article 8 may apply in environmental cases whether the pollution is directly caused by the State or whether State responsibility arises from the failure to regulate private industry properly. Whether the case is analysed in terms of a positive duty on the State to take reasonable and appropriate

measures to secure the applicants' rights under paragraph 1 of Article 8 or in terms of an interference by a public authority to be justified in accordance with paragraph 2, the applicable principles are broadly similar. In both contexts regard must be had to the fair balance that has to be struck between the competing interests of the individual and of the community as a whole; and in both contexts the State enjoys a certain margin of appreciation in determining the steps to be taken to ensure compliance with the Convention. Furthermore, even in relation to the positive obligations flowing from the first paragraph of Article 8, in striking the required balance the aims mentioned in the second paragraph may be of a certain relevance (see *Powell and Rayner*, p. 18, § 41, and *López Ostra* pp. 54-55, § 51, both cited above).

99. The Court considers that in a case such as the present one, involving State decisions affecting environmental issues, there are two aspects to the inquiry which may be carried out by the Court. First, the Court may assess the substantive merits of the government's decision, to ensure that it is compatible with Article 8. Secondly, it may scrutinise the decision-making process to ensure that due weight has been accorded to the interests of the individual.

100. In relation to the substantive aspect, the Court has held that the State must be allowed a wide margin of appreciation. In *Powell and Rayner*, for example, it asserted that it was “certainly not for the Commission or the Court to substitute for the assessment of the national authorities any other assessment of what might be the best policy in this difficult social and technical sphere”, namely the regulation of excessive aircraft noise and the means of redress to be provided to the individual within the domestic legal system. The Court continued that “this is an area where the Contracting States are to be recognised as enjoying a wide margin of appreciation” (p. 19, § 44).

101. In other cases involving environmental issues, for example planning cases, the Court has also held that the State must be allowed a wide margin of appreciation. The Court explained the reasons for this approach in *Buckley v. the United Kingdom*, where the applicant complained that she had been denied planning permission to install a residential caravan on land that she owned (judgment of 25 September 1996, *Reports* 1996-IV, pp. 1291-93, §§ 74-77):

> “74. As is well established in the Court's case-law, it is for the national authorities to make the initial assessment of the 'necessity' for an interference, as regards both the legislative framework and the particular measure of implementation ... Although a margin of appreciation is thereby left to the national authorities, their decision remains subject to review by the Court for conformity with the requirements of the Convention.

The scope of this margin of appreciation is not identical in each case but will vary according to the context ... Relevant factors include the nature of the Convention right in issue, its importance for the individual and the nature of the activities concerned.

75. The Court has already had occasion to note that town and country planning schemes involve the exercise of discretionary judgment in the implementation of policies adopted in the interest of the community ... It is not for the Court to substitute its own view of what would be the best policy in the planning sphere or the most appropriate individual measure in planning cases ... By reason of their direct and continuous contact with the vital forces of their countries, the national authorities are in principle better placed than an international court to evaluate local needs and conditions. In so far as the exercise of discretion involving a multitude of local factors is inherent in the choice and implementation of planning policies, the national authorities in principle enjoy a wide margin of appreciation.

76. The Court cannot ignore, however, that in the instant case the interests of the community are to be balanced against the applicant's right to respect for her 'home', a right which is pertinent to her and her children's personal security and well-being ... The importance of that right for the applicant and her family must also be taken into account in determining the scope of the margin of appreciation allowed to the respondent State.

Whenever discretion capable of interfering with the enjoyment of a Convention right such as the one in issue in the present case is conferred on national authorities, the procedural safeguards available to the individual will be especially material in determining whether the respondent State has, when fixing the regulatory framework, remained within its margin of appreciation. Indeed it is settled case-law that, whilst Article 8 contains no explicit procedural requirements, the decision-making process leading to measures of interference must be fair and such as to afford due respect to the interests safeguarded to the individual by Article 8 ...

77. The Court's task is to determine, on the basis of the above principles, whether the reasons relied on to justify the interference in question are relevant and sufficient under Article 8 § 2."

102. The Court has recognised that, where government policy in the form of criminal laws interferes with a particularly intimate aspect of an individual's private life, the margin of appreciation left to the State will be reduced in scope (see *Dudgeon v. the United Kingdom*, judgment of 22 October 1981, Series A no. 45, p. 21, § 52).

103. The Court is thus faced with conflicting views as to the margin of appreciation to be applied: on the one hand, the Government claim a wide margin on the ground that the case concerns matters of general policy, and, on the other hand, the applicants' claim that where the ability to sleep is affected, the margin is narrow because of the "intimate" nature of the right protected. This conflict of views on the margin of appreciation can be resolved only by reference to the context of a particular case.

104. In connection with the procedural element of the Court's review of cases involving environmental issues, the Court is required to consider all the procedural aspects, including the type of policy or decision involved, the

extent to which the views of individuals (including the applicants) were taken into account throughout the decision-making procedure, and the procedural safeguards available.

B. Appraisal of the facts of the case in the light of the general principles

1. The Chamber's judgment

105. The Chamber found that, overall, the level of noise during the hours 11.30 p.m. to 6 a.m. had increased under the 1993 Scheme. It considered that, in permitting increased levels of noise from 1993 onwards, the government had failed to respect their positive obligation to the applicants, through omitting, either directly or through the commissioning of independent research, to assess critically the importance of the contribution of night flights to the United Kingdom economy. The Chamber further criticised the government for carrying out only limited research into the effects of night flights on local residents prior to the introduction of the 1993 Scheme, noting that the 1992 sleep study was limited to sleep disturbance and made no mention of the problem of sleep prevention. The Chamber did not accept that the "modest" steps taken to mitigate night noise under the 1993 Scheme were capable of constituting "the measures necessary" to protect the applicants. It concluded that "in the absence of any serious attempt to evaluate the extent or impact of the interferences with the applicants' sleep patterns, and generally in the absence of a prior specific and complete study with the aim of finding the least onerous solution as regards human rights, it is not possible to agree that in weighing the interferences against the economic interest of the country – which itself had not been quantified – the government struck the right balance in setting up the 1993 Scheme".

2. The parties' submissions

(a) The Government

106. The Government recognised that night-time noise from aircraft had the capacity to disturb or prevent sleep, but urged the Court to assess critically the applicants' claims that each suffered from a high level of disturbance. In this connection they pointed out that there was a considerable variety in the geographical positions of the applicants and in the levels of night noise to which they were exposed. Furthermore, it was noteworthy that hundreds of thousands of residents of London and the home counties were in a similar position, that the property market in the affected

areas was thriving and that the applicants had not claimed that they were unable to sell their houses and move.

107. The Government stressed that all other principal European hub airports had less severe restrictions on night flights than those imposed at the three London airports. Paris-Charles de Gaulle and Amsterdam-Schiphol had no restrictions at all on the total number of “Chapter 3” aircraft which could operate at night, while Frankfurt had restrictions on landings by Chapter 3 aircraft between 1 a.m. and 4 a.m. If restrictions on night flights at Heathrow were made more stringent, UK airlines would be placed at a significant competitive disadvantage. Since 1988 they had used the scarce night slots permitted at Heathrow for two purposes: a small number were late evening departures on flights which had been delayed but the majority, typically thirteen to sixteen flights a night, were early morning arrivals between 4 a.m. and 6 a.m. of long-haul scheduled flights, mainly from South-East Asia, North America and southern Africa. In recent years the airlines concerned had taken steps to ensure that these arrivals did not land before 4.30 a.m.

The Government submitted that these flights formed an integral part of the network of connecting air services. If they were forced to operate during the day they could provide fewer viable connections with regional services at both ends, making London a less attractive place in which to do business. In any event, daytime capacity at all of London's airports was close to full, and it would be impracticable to re-schedule flights out of the night period.

108. The Government asserted that before 1993 detailed reviews were conducted into a number of aspects of the night restrictions regime. Thus, in July 1990 the Department of Transport commenced an internal review into the restrictions then applying and, in January, October and November 1993, and also in March and June 1995, published Consultation Papers to seek the views of the public and the industries concerned on the need for and effects of night flights and on various proposed modifications to the regime.

The respondents from the airline industry stressed the economic importance of night flights, as set out above. They provided information showing that, in 1993, a typical daily night flight would generate an annual revenue of between GBP 70 and 175 million and an annual profit of up to GBP 15 million. The loss of this revenue and profit would impact severely on the ability of airlines to operate and the cost of air travel by day and night. The Government submitted that the basic components of the economic justification for night flights have never been substantially challenged, either by other respondents to the Consultation Papers or since. Despite accepting the force of the economic justification, the authorities did not go as far as they were invited to by the industry; for example, they did not grant the repeated requests for much larger night noise quotas or a night quota period ending at 5 a.m. Instead, they struck a genuine balance between the interests of the industry and of local residents.

109. The Government stressed that they had also had available, in December 1992, the results of research commissioned in July 1990 into aircraft noise disturbance amongst people living near to Gatwick, Heathrow, Stansted and Manchester Airports ("the 1992 sleep study" – see paragraph 35 above). This study was, and remained, the most comprehensive of its type, and had been preceded by a number of other reports into aircraft noise and sleep disturbance, including detailed interviews with some 1,636 people living near the airports ("the social survey"). The purpose of all this research, culminating in the 1992 sleep study, was to provide information, on as reliable a scientific basis as possible, as to the effects of night-time aircraft noise on sleep. The sleep study showed that external noise levels below 80 dBA were very unlikely to cause any increase in the normal rate of disturbance of someone's sleep; that with external noise levels between 80 and 95 dBA the likelihood of an average person being awakened was about 1 in 75; and that the number of disturbances caused by aircraft noise was so small that it had a negligible effect on overall disturbance rates, although it was possible that the 2 to 3% of the population who were more sensitive to noise disturbance were twice as likely to be woken. According to the social survey, approximately 80% of those living in the Heathrow area had said that they were never or only sometimes woken up for any cause. Of those that were woken, 17% gave aircraft noise as the cause, 16% blamed a partner or a child and another 28.5% gave a variety of different reasons. Approximately 35% of those living near Heathrow said that if woken, for any reason, they found it difficult to get back to sleep.

110. The Government submitted that the changes to the hours of restriction, the extension of the quota restrictions to place limits on many previously exempt types of aircraft and the restrictions on the scheduling for landing or taking off of the noisiest categories of aircraft over a longer night period made an exact comparison between the regimes before and after 1993 impossible.

They recognised that there had been an increase in the number of movements between 6 a.m. and 6.30 a.m. in winter, since this time slot had been subject to restriction before 1993 and now fell outside the quota period. However, the Government contended that, during the core quota period of 11.30 p.m. to 6 a.m., there had been an improvement in the noise environment because of the measures taken, notably the introduction of the quota count system, to encourage the use of quieter aircraft at night.

(b) The applicants

111. The applicants, who accepted the Chamber's judgment as one way of applying the Convention to the facts of the case, underlined that only a very small percentage of flights take place between 11.30 p.m. and 6 a.m., and that there are hardly any flights before 4 a.m. at all, with an average of

four aircraft landing between 4 a.m. and 4.59 a.m. in 2000, and eleven between 5 a.m. and 5.59 a.m.. They maintained that the disturbance caused by these flights was extensive because the applicants and large numbers of others were affected, and it is the nature of sleep disturbance that once people are awake even a few flights will keep them awake.

112. The applicants also pointed out that the night noise they are subjected to is frequently in excess of international standards: the World Health Organisation sets as a guideline value for avoiding sleep disturbance at night a single noise event level of 60 dBA Lmax; almost all the applicants have suffered night noise events in excess of 80 dBA Lmax, and in one case as high as 90 dBA Lmax. Because of the logarithmic nature of the decibel scale, noise energy at 80 dBA Lmax is one hundred times the noise energy at 60 dBA Lmax, and in terms of subjective loudness is four times as loud.

113. The applicants contended that the 1993 Scheme was bound to, and did, result in an increase in night flights and deterioration in the night noise climate, regardless of whether the position was measured by reference to the official night period from 11 p.m. to 7 a.m. or the night quota period from 11.30 a.m. to 6 a.m..

114. The applicants pointed to the absence of any research into sleep prevention before the 1993 Scheme, and added that post-1993 studies and proposals did not amount to an assessment of the effect of night noise on sleep prevention. They further noted the absence of any government-commissioned research into the economic benefits claimed for night flights, seeing this omission as particularly serious given that many of the world's leading business centres (for example, Berlin, Zürich, Munich, Hamburg and Tokyo) have full night-time passenger curfews of between seven and eight hours.

3. The third parties

115. British Airways, whose submissions were supported by the British Air Transport Association (BATA) and the International Air Transport Association (IATA), submitted that night flights at Heathrow play a vital role in the United Kingdom's transport infrastructure, and contribute significantly to the productivity of the United Kingdom economy and the living standards of United Kingdom citizens. They contended that a ban on, or reduction in, night flights would cause major and disproportionate damage to British Airways' business, and would reduce consumer choice. The loss of night flights would cause significant damage to the United Kingdom economy.

4. The Court's assessment

116. The case concerns the way in which the applicants were affected by the implementation in 1993 of the new scheme for regulating night flights at

Heathrow. The 1993 Scheme was latest in the series of restrictions on night flights which began at Heathrow in 1962 and replaced the previous five-year 1988 Scheme. Its aims included, according to the 1993 Consultation Paper (see paragraph 36 above), both protection of local communities from excessive night noise, and taking account of the wider economic implications. The undertaking given by the government in 1988 “not to allow a worsening of noise at night, and ideally to improve it” was maintained (see paragraphs 41 and 43 above). Specifically, the scheme replaced the earlier system of movement limitations with a regime which gave aircraft operators a choice, through the quota count, as to whether to fly fewer noisier aircraft, or more less noisy types (for details, see paragraphs 44-46 above). Although modified in some respects following various judicial review proceedings (see paragraphs 47-50 and 80-83 above) and as a result of further studies and consultations (see paragraphs 51-69 above), the quota count system introduced in 1993 has remained in place to the present day, the authorities continuing to monitor the situation with a view to possible improvements (see paragraphs 70-75 above).

117. The 1993 Scheme accepted the conclusions of the 1992 sleep study (see paragraph 35 above) that for the large majority of people living near airports there was no risk of substantial sleep disturbance due to aircraft noise and that only a small percentage of individuals (some 2 to 3%) were more sensitive than others. On this basis, disturbances caused by aircraft noise were regarded as negligible in relation to overall normal disturbance rates (see paragraph 40 above). The 1992 sleep study continued to be relied upon by the government in their 1998/99 review of the regulations for night flights, when it was acknowledged that further research was necessary, in particular as regards sleep prevention, and a number of further studies on the subject were commissioned (see paragraphs 58-59 and 73 above).

118. The Court has no doubt that the implementation of the 1993 Scheme was susceptible of adversely affecting the quality of the applicants' private life and the scope for their enjoying the amenities of their respective homes, and thus their rights protected by Article 8 of the Convention. Each of the applicants has described the way in which he or she was affected by the changes brought about by the 1993 Scheme at the relevant time (see paragraphs 11-26 above), and the Court sees no reason to doubt the sincerity of their submissions in this respect. It is true that the applicants have not submitted any evidence in support of the degree of discomfort suffered, in particular they have not disproved the Government's indications as to the “objective” daytime noise contour measured at each applicant's home (ibid.). However, as the Government themselves admit, and as is evident from the 1992 sleep study on which they rely, sensitivity to noise includes a subjective element, a small minority of people being more likely than others to be woken or otherwise disturbed in their sleep by aircraft noise at night. The discomfort caused to the individuals concerned will therefore depend

not only on the geographical location of their respective homes in relation to the various flight paths, but also on their individual disposition to be disturbed by noise. In the present case the degree of disturbance may vary somewhat from one applicant to the other, but the Court cannot follow the Government when they seem to suggest that the applicants were not, or not considerably, affected by the scheme at issue.

119. It is clear that in the present case the noise disturbances complained of were not caused by the State or by State organs, but that they emanated from the activities of private operators. It may be argued that the changes brought about by the 1993 Scheme are to be seen as a direct interference by the State with the Article 8 rights of the persons concerned. On the other hand, the State's responsibility in environmental cases may also arise from a failure to regulate private industry in a manner securing proper respect for the rights enshrined in Article 8 of the Convention. As noted above (see paragraph 98), broadly similar principles apply whether a case is analysed in terms of a positive duty on the State or in terms of an interference by a public authority with Article 8 rights to be justified in accordance with paragraph 2 of this provision. The Court is not therefore required to decide whether the present case falls into the one category or the other. The question is whether, in the implementation of the 1993 policy on night flights at Heathrow Airport, a fair balance was struck between the competing interests of the individuals affected by the night noise and the community as a whole.

120. The Court notes at the outset that in previous cases in which environmental questions gave rise to violations of the Convention, the violation was predicated on a failure by the national authorities to comply with some aspect of the domestic regime. Thus, in *López Ostra*, the waste-treatment plant at issue was illegal in that it operated without the necessary licence, and was eventually closed down (*López Ostra*, cited above, pp. 46-47, §§ 16-22). In *Guerra and Others*, the violation was also founded on an irregular position at the domestic level, as the applicants had been unable to obtain information that the State was under a statutory obligation to provide (*Guerra and Others*, cited above, p. 219, §§ 25-27).

This element of domestic irregularity is wholly absent in the present case. The policy on night flights which was set up in 1993 was challenged by the local authorities, and was found, after a certain amount of amendment, to be compatible with domestic law. The applicants do not suggest that the policy (as amended) was in any way unlawful at a domestic level, and indeed they have not exhausted domestic remedies in respect of any such claim. Further, they do not claim that any of the night flights which disturbed their sleep violated the relevant regulations, and again any such claim could have been pursued in the domestic courts under section 76(1) of the Civil Aviation Act 1982.

121. In order to justify the night flight scheme in the form in which it has operated since 1993, the Government refer not only to the economic interests of the operators of airlines and other enterprises as well as their clients, but also, and above all, to the economic interests of the country as a whole. In their submission these considerations make it necessary to impinge, at least to a certain extent, on the Article 8 rights of the persons affected by the scheme. The Court observes that according to the second paragraph of Article 8 restrictions are permitted, *inter alia*, in the interests of the economic well-being of the country and for the protection of the rights and freedoms of others. It is therefore legitimate for the State to have taken the above economic interests into consideration in the shaping of its policy.

122. The Court must consider whether the State can be said to have struck a fair balance between those interests and the conflicting interests of the persons affected by noise disturbances, including the applicants. Environmental protection should be taken into consideration by States in acting within their margin of appreciation and by the Court in its review of that margin, but it would not be appropriate for the Court to adopt a special approach in this respect by reference to a special status of environmental human rights. In this context the Court must revert to the question of the scope of the margin of appreciation available to the State when taking policy decisions of the kind at issue (see paragraph 103 above).

123. The Court notes that the introduction of the 1993 Scheme for night flights was a general measure not specifically addressed to the applicants in this case, although it had obvious consequences for them and other persons in a similar situation. However, the sleep disturbances relied on by the applicants did not intrude into an aspect of private life in a manner comparable to that of the criminal measures considered in *Dudgeon* to call for an especially narrow scope for the State's margin of appreciation (see *Dudgeon*, cited above, p. 21, § 52, and paragraph 102 above). Rather, the normal rule applicable to general policy decisions (see paragraph 97 above) would seem to be pertinent here, the more so as this rule can be invoked even in relation to individually addressed measures taken in the framework of a general policy, such as in *Buckley*, cited above (see paragraph 101). Whilst the State is required to give due consideration to the particular interests, the respect for which it is obliged to secure by virtue of Article 8, it must in principle be left a choice between different ways and means of meeting this obligation. The Court's supervisory function being of a subsidiary nature, it is limited to reviewing whether or not the particular solution adopted can be regarded as striking a fair balance.

124. In the present case the Court first notes the difficulties in establishing whether the 1993 Scheme actually led to a deterioration of the night noise climate. The applicants contend that it did; the Government disagree. Statements in the 1998 Consultation Paper suggest that, generally,

the noise climate around Heathrow may have improved during the night quota period, but probably deteriorated over the full night period (see paragraph 61 above). The Court is not able to make any firm findings on this point. It notes the dispute between the parties as to whether aircraft movements or quota counts should be employed as the appropriate yardstick for measuring night noise. However, it finds no indication that the authorities' decision to introduce a regime based on the quota count system was as such incompatible with Article 8.

125. Whether in the implementation of that regime the right balance has been struck in substance between the Article 8 rights affected by the regime and other conflicting community interests depends on the relative weight given to each of them. The Court accepts that in this context the authorities were entitled, having regard to the general nature of the measures taken, to rely on statistical data based on average perception of noise disturbance. It notes the conclusion of the 1993 Consultation Paper that due to their small number sleep disturbances caused by aircraft noise could be treated as negligible in comparison to overall normal disturbance rates (see paragraph 40 above). However, this does not mean that the concerns of the people affected were totally disregarded. The very purpose of maintaining a scheme of night flight restrictions was to keep noise disturbance at an acceptable level for the local population living in the area near the airport. Moreover, there was a realisation that in view of changing conditions (increase of air transport, technological advances in noise prevention, development of social attitudes, etc.) the relevant measures had to be kept under constant review.

126. As to the economic interests which conflict with the desirability of limiting or halting night flights in pursuance of the above aims, the Court considers it reasonable to assume that those flights contribute at least to a certain extent to the general economy. The Government have produced to the Court reports on the results of a series of inquiries on the economic value of night flights, carried out both before and after the 1993 Scheme. Even though there are no specific indications about the economic cost of eliminating specific night flights, it is possible to infer from those studies that there is a link between flight connections in general and night flights. In particular, the Government claim that some flights from Far-East destinations to London could arrive only by departing very late at night, giving rise to serious passenger discomfort and a consequent loss of competitiveness. One can readily accept that there is an economic interest in maintaining a full service to London from distant airports, and it is difficult, if not impossible, to draw a clear line between the interests of the aviation industry and the economic interests of the country as a whole. However, airlines are not permitted to operate at will, as substantial limitations are put on their freedom to operate, including the night restrictions which apply at Heathrow. The Court would note here that the 1993 Scheme which was

eventually put in place was stricter than that envisaged in the 1993 Consultation Paper, as even the quietest aircraft were included in the quota count system. The Government have in addition resisted calls for a shorter night quota period, or for the lifting of night restrictions. The Court also notes subsequent modifications to the system involving further limitations for the operators, including, *inter alia*, the addition of an overall maximum number of permitted aircraft movements (see paragraph 50 above) and reduction of the available quota count points (see paragraph 66 above).

127. A further relevant factor in assessing whether the right balance has been struck is the availability of measures to mitigate the effects of aircraft noise generally, including night noise. A number of measures are referred to above (see paragraph 74). The Court also notes that the applicants do not contest the substance of the Government's claim that house prices in the areas in which they live have not been adversely affected by the night noise. The Court considers it reasonable, in determining the impact of a general policy on individuals in a particular area, to take into account the individuals' ability to leave the area. Where a limited number of people in an area (2 to 3% of the affected population, according to the 1992 sleep study) are particularly affected by a general measure, the fact that they can, if they choose, move elsewhere without financial loss must be significant to the overall reasonableness of the general measure.

128. On the procedural aspect of the case, the Court notes that a governmental decision-making process concerning complex issues of environmental and economic policy such as in the present case must necessarily involve appropriate investigations and studies in order to allow them to strike a fair balance between the various conflicting interests at stake. However, this does not mean that decisions can only be taken if comprehensive and measurable data are available in relation to each and every aspect of the matter to be decided. In this respect it is relevant that the authorities have consistently monitored the situation, and that the 1993 Scheme was the latest in a series of restrictions on night flights which stretched back to 1962. The position concerning research into sleep disturbance and night flights is far from static, and it was the government's policy to announce restrictions on night flights for a maximum of five years at a time, each new scheme taking into account the research and other developments of the previous period. The 1993 Scheme had thus been preceded by a series of investigations and studies carried out over a long period of time. The particular new measures introduced by that scheme were announced to the public by way of a Consultation Paper which referred to the results of a study carried out for the Department of Transport, and which included a study of aircraft noise and sleep disturbance. It stated that the quota was to be set so as not to allow a worsening of noise at night, and ideally to improve the situation. This paper was published in January 1993 and sent to bodies representing the aviation industry and people living near

airports. The applicants and persons in a similar situation thus had access to the Consultation Paper, and it would have been open to them to make any representations they felt appropriate. Had any representations not been taken into account, they could have challenged subsequent decisions, or the scheme itself, in the courts. Moreover, the applicants are, or have been, members of HACAN (see paragraph 1 above), and were thus particularly well-placed to make representations**.**

129. In these circumstances the Court does not find that, in substance, the authorities overstepped their margin of appreciation by failing to strike a fair balance between the right of the individuals affected by those regulations to respect for their private life and home and the conflicting interests of others and of the community as a whole, nor does it find that there have been fundamental procedural flaws in the preparation of the 1993 regulations on limitations for night flights.

130. There has accordingly been no violation of Article 8 of the Convention.

II. ALLEGED VIOLATION OF ARTICLE 13 OF THE CONVENTION

131. The applicants contended that judicial review was not an effective remedy in relation to their rights under Article 8 of the Convention, in breach of Article 13.

Article 13 provides:

> "Everyone whose rights and freedoms as set forth in [the] Convention are violated shall have an effective remedy before a national authority notwithstanding that the violation has been committed by persons acting in an official capacity."

132. The Government disputed the applicants' contention that there had been a violation of Article 13.

A. The Chamber's judgment

133. In its judgment of 2 October 2001, the Chamber held that the scope of review by the domestic courts did not allow consideration of whether the increase in night flights under the 1993 Scheme represented a justifiable limitation on the Article 8 rights of those who live in the vicinity of Heathrow Airport (see paragraphs 115 and 116 above).

B. The parties' submissions

1. The Government

134. In their letter requesting that the case be referred to the Grand Chamber, the Government made no reference to Article 13 of the

Convention. In subsequent communications they referred back to the pleadings before the Commission and the Chamber, summarised at paragraphs 112 and 113 of the Chamber's judgment, in which they contended that Article 13 was not applicable or, in the alternative, that the scope of judicial review was sufficient to satisfy the requirements of that provision. At the hearing of 13 November 2002 the Government underlined that the present case concerned positive rather than negative obligations, and pointed to similarities between the judicial review proceedings in the United Kingdom and the Convention approach.

2. The applicants

135. The applicants contended, as they had before the Chamber, that they had no private-law rights in relation to excessive night noise, as a consequence of the statutory exclusion of liability in section 76 of the Civil Aviation Act 1982. They submitted that the limits inherent in an application for judicial review meant that it was not an effective remedy. They added that in *R. (Daly) v. Secretary of State for the Home Department* ([2001] 2 Appeal Cases 532), the House of Lords had confirmed the inadequacy of the approach in *R. v. Minister of Defence, ex parte Smith* ([1996] Queen's Bench Reports 517).

C. The third parties

136. The third parties did not comment on the Article 13 issues.

D. The Court's assessment

137. As the Chamber observed, Article 13 has been consistently interpreted by the Court as requiring a remedy in domestic law only in respect of grievances which can be regarded as "arguable" in terms of the Convention (see, for example, *Boyle and Rice v. the United Kingdom*, judgment of 27 April 1988, Series A no. 131, pp. 23-24, § 54). In the present case, it has not found a violation of Article 8, but the Court considers that confronted with a finding by the Chamber that the Article 8 issues were admissible and indeed that there was a violation of that provision, it must accept that the claim under Article 8 was arguable. The complaint under Article 13 must therefore be considered.

138. The Court would first reiterate that Article 13 does not go so far as to guarantee a remedy allowing a Contracting State's laws to be challenged before a national authority on the ground of being contrary to the Convention (see *Costello-Roberts v. the United Kingdom*, judgment of 25 March 1993, Series A no. 247-C, p. 62, § 40). Similarly, it does not allow a challenge to a general policy as such. Where an applicant has an

arguable claim to a violation of a Convention right, however, the domestic regime must afford an effective remedy (ibid., p. 62, § 39).

139. As the Chamber found, section 76 of the 1982 Act prevents actions in nuisance in respect of excessive noise caused by aircraft at night. The applicants complain about the flights which were permitted by the 1993 Scheme, and which were in accordance with the relevant regulations. No action therefore lay in trespass or nuisance in respect of lawful night flights.

140. The question which the Court must address is whether the applicants had a remedy at national level to "enforce the substance of the Convention rights ... in whatever form they may happen to be secured in the domestic legal order" (see *Vilvarajah and Others v. the United Kingdom,* judgment of 30 October 1991, Series A no. 215, pp. 38-40, §§ 117-27). The scope of the domestic review in *Vilvarajah*, which concerned immigration, was relatively broad because of the importance domestic law attached to the matter of physical integrity. It was on this basis that judicial review was held to comply with the requirements of Article 13. In contrast, in *Smith and Grady v. the United Kingdom* (nos. 33985/96 and 33986/96, §§ 135-39, ECHR 1999-VI), the Court concluded that judicial review was not an effective remedy on the ground that the domestic courts defined policy issues so broadly that it was not possible for the applicants to make their Convention points regarding their rights under Article 8 in the domestic courts.

141. The Court observes that judicial review proceedings were capable of establishing that the 1993 Scheme was unlawful because the gap between government policy and practice was too wide (see *R. v. Secretary of State for Transport, ex parte Richmond LBC (no. 2)* [1995] Environmental Law Reports 390). However, it is clear, as noted by the Chamber, that the scope of review by the domestic courts was limited to the classic English public-law concepts, such as irrationality, unlawfulness and patent unreasonableness, and did not at the time (that is, prior to the entry into force of the Human Rights Act 1998) allow consideration of whether the claimed increase in night flights under the 1993 Scheme represented a justifiable limitation on the right to respect for the private and family lives or the homes of those who live in the vicinity of Heathrow Airport.

142. In these circumstances, the Court considers that the scope of review by the domestic courts in the present case was not sufficient to comply with Article 13.

There has therefore been a violation of Article 13 of the Convention.

III. APPLICATION OF ARTICLE 41 OF THE CONVENTION

143. Article 41 of the Convention provides:

> "If the Court finds that there has been a violation of the Convention or the Protocols thereto, and if the internal law of the High Contracting Party concerned allows only partial reparation to be made, the Court shall, if necessary, afford just satisfaction to the injured party."

A. Damage

144. The applicants, referring to the Chamber's judgment, considered that a modest award should be made in relation to non-pecuniary damage.

145. The Government took the view that a finding of a violation would constitute in itself sufficient just satisfaction in respect of a violation of either Article 8 or Article 13.

146. The Chamber awarded the applicants the sum of 4,000 pounds sterling (GBP) each for non-pecuniary damage in respect of the violations it found of Articles 8 and 13.

147. The Court has found a violation of the procedural right to an effective domestic remedy under Article 13 of the Convention in respect of the applicants' complaints under Article 8, but no violation of the substantive right to respect for private life, family life, home and correspondence under Article 8 itself.

148. The Court notes that in *Camenzind v. Switzerland* (judgment of 16 December 1997, *Reports* 1997-VIII, pp. 2897-98, § 57) the Court found a violation of Article 13 in relation to the applicant's claim under Article 8, but no substantive violation of the Convention. In that case the Court considered that the judgment constituted in itself sufficient just satisfaction for the alleged non-pecuniary damage.

Furthermore, in the present case, the violation of Article 13 derived, not from the applicants' lack of any access to the British courts to challenge the impact on them of the State's policy on night flights at Heathrow Airport, but rather from the overly narrow scope of judicial review at the time, which meant that the remedy available under British law was not an "effective" one enabling them to ventilate fully the substance of their complaint under Article 8 of the Convention (see paragraphs 140-42 above).

This being so, the Court considers that, having regard to the nature of the violation found, the finding of a violation constitutes in itself sufficient just satisfaction in respect of any non-pecuniary damage.

B. Costs and expenses

149. The applicants claimed a total of GBP 153,867.56 plus GBP 24,929.55 value-added tax (VAT) in respect of the costs before the

Chamber, and an additional GBP 154,941.48 plus GBP 23,976.82 VAT (totalling GBP 178,918.30) before the Grand Chamber.

150. The Government made a number of comments on the costs and expenses before the Grand Chamber. They challenged the rates charged by the solicitors involved, and considered that the time billed by the solicitors was excessive. They also considered that the fees charged by counsel and the applicants' experts were excessive. Overall, they suggested GBP 109,000 as an appropriate figure for the Grand Chamber costs and expenses.

151. The Chamber reduced the costs and expenses claimed by the applicants in the proceedings up to then from GBP 153,867.56 to GBP 70,000.

152. Costs and expenses will not be awarded under Article 41 unless it is established that they were actually and necessarily incurred and are also reasonable as to quantum (see The Sunday Times *v. the United Kingdom (no. 1)* (Article 50), judgment of 6 November 1980, Series A no. 38, p. 13, § 23). Furthermore, legal costs are only recoverable in so far as they relate to the violation found (see *Beyeler v. Italy* (just satisfaction) [GC], no. 33202/96, § 27, 28 May 2002).

153**.** The Court notes that whilst the Chamber found a violation of both Articles 8 and 13 of the Convention, the Grand Chamber has found solely a violation of Article 13 in relation to the applicants' claim under Article 8. Whilst this difference between the findings should be reflected in the award of costs, the Grand Chamber should not lose sight of the fact that Article 13 cannot stand alone. Without an “arguable claim” in respect of the substantive issues, the Court would have been unable to consider Article 13 (see, for example, *Boyle and Rice*, cited above, pp. 23-24, §§ 52 and 54). The award of costs should therefore reflect the work undertaken by the applicants' representatives on the Article 8 issues to a certain extent, even if not to the same extent as if a violation of Article 8 had also been found.

154**.** The Court awards the applicants the sum of 50,000 euros, including VAT, in respect of costs and expenses.

C. Default interest

155. The Court considers it appropriate that the default interest should be based on the marginal lending rate of the European Central Bank, to which should be added three percentage points.

FOR THESE REASONS, THE COURT

1. *Holds* by twelve votes to five that there has been no violation of Article 8 of the Convention;

2. *Holds* by sixteen votes to one that there has been a violation of Article 13 of the Convention;

3. *Holds* by fifteen votes to two that the finding of a violation of Article 13 of the Convention constitutes in itself sufficient just satisfaction for any damage sustained by the applicants;

4. *Holds* unanimously
(a) that the respondent State is to pay the applicants, within three months, EUR 50,000 (fifty thousand euros) in respect of costs and expenses, to be converted into pounds sterling at the rate applicable on the date of settlement, including any tax that may be chargeable;
(b) that from the expiry of the above-mentioned three months until settlement simple interest shall be payable on the above amount at a rate equal to the marginal lending rate of the European Central Bank during the default period plus three percentage points;

5. *Dismisses* by thirteen votes to four the remainder of the applicants' claim for just satisfaction.

Done in English and in French, and delivered at a public hearing in the Human Rights Building, Strasbourg, on 8 July 2003.

Luzius WILDHABER
President

Paul MAHONEY
Registrar

In accordance with Article 45 § 2 of the Convention and Rule 74 § 2 of the Rules of Court, the following dissenting opinions are annexed to this judgment:

(a) joint dissenting opinion of Mr Costa, Mr Ress, Mr Türmen, Mr Zupančič and Mrs Steiner;

(b) dissenting opinion of Sir Brian Kerr.

L.W.
P.J.M.

JOINT DISSENTING OPINION OF JUDGES COSTA, RESS, TÜRMEN, ZUPANČIČ AND STEINER

I. Introduction

We regret that we cannot adhere to the majority's view that there has been no violation of Article 8 of the European Convention on Human Rights in this case. We have reached our joint dissenting standpoint primarily from our reading of the current stage of development of the pertinent case-law. In addition, the close connection between human rights protection and the urgent need for a decontamination of the environment leads us to perceive health as the most basic human need and as pre-eminent. After all, as in this case, what do human rights pertaining to the privacy of the home mean if, day and night, constantly or intermittently, it reverberates with the roar of aircraft engines?

1. It is true that the original text of the Convention does not yet disclose an awareness of the need for the protection of environmental human rights[1]. In the 1950s, the universal need for environmental protection was not yet apparent. Historically, however, environmental considerations are by no means unknown to our unbroken and common legal tradition[2] whilst, thirty-one years ago, the Declaration of the United Nations Conference on the Human Environment stated as its first principle:

> "... Man has the fundamental right to freedom, equality and adequate conditions of life, in an environment of quality that permits a life of dignity and well-being ..."[3]

1. The idiom "environmental protection" appears in fifty-seven of our cases. The phrase "environmental human rights" appears for the first time in the majority judgment.
2. For example, the extraordinarily sensitive doctrine concerning environmental nuisances goes back to Roman law. Roman law classified these nuisances as *immissiones in alienum*. Dig.8.5.8.5 Ulpianus 17 ad ed.; see http://www.thelatinlibrary.com/justinian/digest8.shtml
3. *Declaration of the United Nations Conference on the Human Environment*, 1972; see http://www.unep.org/Documents/Default.asp?DocumentID=97&ArticleID=1503. It is interesting that from the very beginning environmental protection has been linked to personal well-being (health). See note 3, p. 45.

The European Union's Charter of Fundamental Rights (even though it does not at present have binding legal force) provides an interesting illustration of the point. Article 37 of the Charter provides:

> “A high level of environmental protection and the improvement of the quality of the environment must be integrated into the policies of the Union and ensured in accordance with the principle of sustainable development.”

These recommendations show clearly that the member States of the European Union want a high level of protection and better protection, and expect the Union to develop policies aimed at those objectives. On a broader plane the Kyoto Protocol makes it patent that the question of environmental pollution is a supra-national one, as it knows no respect for the boundaries of national sovereignty[1]. This makes it an issue *par excellence* for international law – and a fortiori for international jurisdiction. In the meanwhile, many supreme and constitutional courts have invoked constitutional vindication of various aspects of environmental protection – on these precise grounds[2]. We believe that this concern for environmental protection shares common ground with the general concern for human rights.

II. Development of the case-law

2. As the Court has often underlined: “The Convention is a living instrument, to be interpreted in the light of present-day conditions” (see, among many other authorities, *Airey v. Ireland*, judgment of 9 October 1979, Series A no. 32, pp. 14-16, § 26, and *Loizidou v. Turkey* (preliminary objections), judgment of 23 March 1995, Series A no. 310, pp. 26-27, § 71). This “evolutive” interpretation by the Commission and the Court of various Convention requirements has generally been “progressive”, in the sense that they have gradually extended and raised the level of protection afforded to the rights and freedoms guaranteed by the Convention to develop the “European public order”. In the field of environmental human rights, which was practically unknown in 1950, the Commission and the Court have increasingly taken the view that Article 8 embraces the right to a healthy environment, and therefore to protection against pollution and nuisances caused by harmful chemicals, offensive smells, agents which precipitate respiratory ailments, noise and so on.

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1. Kyoto Protocol to the United Nations Framework Convention on Climate Change, see “the Convention and Kyoto Protocol” at http://unfccc.int/resource/convkp.html.
2. See, for example, *Compendium of summaries of judicial decisions in environment related cases* (SACEP/UNEP/NORAD Publication Series on Environmental Law and Policy no. 3), Compendium of summaries at http://www.unescap.org/drpad/vc/document/compendium/index.htm; EPA search results at http://oaspub.epa.gov/webi/meta_first_new2.try_these_first.

3. In previous cases concerning protection against aircraft noise the Commission did not hesitate to rule that Article 8 was applicable and declared complaints of a violation of that provision admissible – in *Arrondelle* and *Baggs*, for example. In *Arrondelle v. the United Kingdom* (no. 7889/77, Commission decision of 15 July 1980, Decisions and Reports (DR) 19, p. 186) the applicant's house was just over one and a half kilometres from the end of the runway at Gatwick Airport. In *Baggs v. the United Kingdom* (no. 9310/81, Commission decision of 16 October 1985, DR 44, p. 13) the applicant's property was 400 metres away from the south runway of Heathrow Airport. These two applications, which were declared admissible, ended with friendly settlements. While that does not mean that there was a violation of the Convention, it does show that the respondent Government accepted at that time that there was a real problem. And it was for purely technical reasons that the Court itself, in *Powell and Rayner v. the United Kingdom* (judgment of 21 February 1990, Series A no. 172), which also concerned flights in and out of Heathrow, refused to look into the Article 8 issue.

4. The Court has given clear confirmation that Article 8 of the Convention guarantees the right to a healthy environment: it found violations of Article 8, on both occasions unanimously, in *López Ostra v. Spain* (judgment of 9 December 1994, Series A no. 303-C) and *Guerra and Others v. Italy* (judgment of 19 February 1998, *Reports of Judgments and Decisions* 1998-I). The first of those cases concerned nuisances (smells, noise and fumes) caused by a waste-water treatment plant close to the applicant's home which had affected her daughter's health. The other concerned harmful emissions from a chemical works which presented serious risks to the applicants, who lived in a nearby municipality.

5. The Grand Chamber's judgment in the present case, in so far as it concludes, contrary to the Chamber's judgment of 2 October 2001, that there was no violation of Article 8, seems to us to deviate from the above developments in the case-law and even to take a step backwards. It gives precedence to economic considerations over basic health conditions in qualifying the applicants' "sensitivity to noise" as that of a small minority of people (see paragraph 118 of the judgment). The trend of playing down such sensitivity – and more specifically concerns about noise and disturbed sleep – runs counter to the growing concern over environmental issues all over Europe and the world. A simple comparison of the above-mentioned cases (*Arrondelle*, *Baggs* and *Powell and Rayner*) with the present judgment seems to show that the Court is turning against the current.

III. The positive obligation of the State

6. The Convention protects the individual against direct abuses of power by the State authorities. Typically, the environmental aspect of the

individual's human rights is not threatened by direct government action. Indirectly, however, the question is often whether the State has taken the necessary measures to protect health and privacy. Even assuming it has, direct State action may take the form of permitting, as here, the operation of an airport under certain conditions. The extent of permissible direct State interference and of the State's positive obligations is not easy to determine in such situations, but these difficulties should not undermine the overall protection which the States have to ensure under Article 8.

7. Thus, under domestic law, the regulatory power of the State is involved in protecting the individual against the macroeconomic and commercial interests that cause pollution. The misleading variation in this indirect juxtaposition of the individual and the State therefore derives from the fact that the State is under an obligation to act and omits to do so (or does so in violation of the principle of proportionality). In this respect, we have come a long way from the situation considered by this Court in *Powell and Rayner* (cited above, pp. 9-10, § 15), in which the Noise Abatement Act specifically exempted aircraft noise from its protection. The issue in the context of domestic law is, therefore, whether the State has done anything or enough.

8. At least since *Powell and Rayner* (p. 18, § 41), the key issue has been the positive obligation of the State.

9. The majority tries to distinguish the present case from *Dudgeon v. the United Kingdom* (judgment of 22 October 1981, Series A no. 45), which dealt with the sexual intimacy aspect of the applicant's private life. In *Dudgeon* (p. 21, § 52) it is said: “The present case concerns a most intimate aspect of private life. Accordingly, there must exist particularly serious reasons before interferences on the part of the public authorities can be legitimate for the purposes of paragraph 2 of Article 8.” The majority judgment differentiates this case from *Dudgeon* by saying: “the sleep disturbances relied on by the applicants did not intrude into an aspect of private life in a manner comparable to that of the criminal measures considered in *Dudgeon* to call for an especially narrow scope for the State's margin of appreciation” (see paragraph 123 of the judgment).

10. It is logical that there be an inverse relationship between the importance of the right to privacy in question on the one hand and the permissible intensity of the State's interference on the other hand. It is also true that sexual intimacy epitomises the innermost concentric circle of private life where the individual should be left in peace unless he interferes with the rights of others. However, it is not logical to infer from this that the proportionality doctrine of inverse relationship between the importance of the right to privacy and the permissible interference should be limited to sexual intimacy. Other aspects of privacy, such as health, may be just as “intimate”, albeit much more vital.

11. Privacy is a heterogeneous prerogative. The specific contours of privacy can be clearly distinguished and perceived only when it is being defended against different kinds of encroachments. Moreover, privacy is an aspect of the person's general well-being and not necessarily only an end in itself. The intensity of the State's permissible interference with the privacy of the individual and his or her family should therefore be seen as being in inverse relationship with the damage the interference is likely to cause to his or her mental and physical health. The point, in other words, is not that the sexual life of the couple whose home reverberates with the noise of aircraft engines may be seriously affected. The thrust of our argument is that "health as a state of complete physical, mental and social well-being" is, in the specific circumstances of this case, a precondition to any meaningful privacy, intimacy, etc., and cannot be unnaturally separated from it[1]. To maintain otherwise amounts to a wholly artificial severance of privacy and of general personal well-being. Of course, each case must be decided on its own merits and by taking into account the totality of its specific circumstances. In this case, however, it is clear that the circles of the protection of health and of the safeguarding of privacy do intersect and do overlap.

12. We do not agree with the majority's position taken in paragraph 123 of the Grand Chamber judgment and especially not with the key language *in fine* where the majority considers: "Whilst the State is required to give due consideration to the particular interests the respect for which it is obliged to secure by virtue of Article 8, it must in principle be left a choice between different ways and means of meeting this obligation. The Court's supervisory function being of a subsidiary nature, it is limited to reviewing whether or not the particular solution adopted can be regarded as striking a fair balance." When it comes to such intimate personal situations as the constant disturbance of sleep at night by aircraft noise there is a positive duty on the State to ensure as far as possible that ordinary people enjoy normal sleeping conditions. It has not been demonstrated that the applicants are capricious, and even if their "sensitivity to noise" and "disposition to be disturbed by noise" may be called "subjective", the Court agreed that they were affected in their ability to sleep "considerably ... by the scheme at issue" (see paragraph 118 of the judgment).

13. It is significant in this respect that under Article 3 sleep deprivation may be considered as an element of inhuman and degrading treatment or even torture[2]. Already, in the inter-State case of *Ireland v. the United*

1. WHO definition of health, see http://www.who.int/about/definition/en/.
2. In *Selmouni v France*, judgment of 28 July 1999, § 97, we decided to adhere to the definition of torture given in Article 1 of the United Nations Convention against Torture. It therefore makes sense to take into account that excessive noise may in fact amount to "severe pain or suffering, whether physical or mental". See, for example, paragraph 257 referring to "sounding of loud music for prolonged periods, sleep deprivation for prolonged

Kingdom (judgment of 18 January 1978, Series A no. 25, p. 41, § 96), the Court held, *inter alia*, that "... holding the detainees in a room where there was a continuous loud and hissing noise ..." constituted a practice of inhuman and degrading treatment[1]. In the light of the subsequent development of our case-law in *Selmouni v. France* ([GC], no. 25803/94, § 97, ECHR 1999-V), the same treatment would now most probably be considered as torture. The present case does not involve torture or inhuman and degrading treatment, and we do not suggest that the complaint could possibly be reclassified under Article 3 of the Convention. Nevertheless, we think that the problem of noise, when it seriously disturbs sleep, does interfere with the right to respect for private and, under specific circumstances, family life, as guaranteed by Article 8, and may therefore constitute a violation of said Article, depending in particular on its intensity and duration.

14. We also find it inconsistent that the judgment (in paragraph 126) should take into account "serious passenger discomfort" whereas it downgrades (see paragraph 118) the discomfort of all the residents, who are exposed to aircraft noise to a "subjective element [of] a small minority of people being more likely than others to be woken or otherwise disturbed in their sleep ...". We do not find it persuasive to engage in the balancing exercise employing the proportionality doctrine in order to show that the abstract majority's interest outweighs the concrete "subjective element of a small minority of people". According to the World Health Organisation (WHO) Guidelines[2], measurable effects of noise on sleep start at noise levels of about 30 dBLA. These criteria are objective. They show that this susceptibility to noise is not "subjective" in the sense of being due to over-sensitivity or capriciousness[3]. Indeed, one of the important functions of human rights protection is to protect "small minorities" whose "subjective element" makes them different from the majority.

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periods" in "Concluding observations of the Committee against Torture: Israel. 09.05.97. A/52/44, paras. 253-260. (Concluding Observations/Comments) at http://www.unhchr.ch/tbs/doc.nsf/9c663e9ef8a0d080c12565a9004db9f7/69b6685c93d9f25180256498005063da?OpenDocument.

1. Similar considerations played a role in *Kalashnikov v. Russia*, no. 47095/99, ECHR 2002-VI.

2. *Guidelines for Community Noise* – Chapter 4 at http://www.who.int/environmental_information/Noise/Commnoise4.htm; see also Environmental Protection Agency of Ireland at http://www.epa.ie/Noise/default.htm.

3. The guidelines are based on a combination of values of 30 dBLA and 45 dBLA maximum. To protect sensitive persons, a still lower guideline value would be preferred when the background level is low. In the case before the Court, however, almost all the applicants have suffered from night noise events in excess of 80 dBLA and in one case as high as 90 dBLA max. It is noteworthy that the judgment in its assessment did not take into account these international standards concerning the effects noise has on sleep, although the relevant data were available in the file.

15. According to the Consultation Paper published by the government in November 1998, "any value attached to a marginal night flight had to be weighed against the environmental disadvantages. These could not be estimated in monetary terms, but it was possible, drawing on a 1992 sleep study, to estimate the numbers of people likely to be awakened". The 1992 sleep study was limited to sleep disturbances and did not even take into account the problems of those who had been unable to get to sleep in the first place. It is noteworthy that the government's claims in respect of the country's economic well-being are based on reports prepared by the aviation industry. The government did not make any serious attempt to assess the impact of aircraft noise on the applicants' sleep. When the 1993 Scheme was introduced, only very limited research existed on the nature of sleep disturbance and prevention. In this respect, we agree with the findings in the Chamber's judgment (paragraphs 103-06). Nor has the government really shown that it has explored all the alternatives, such as using more distant airports.

16. In principle, the general reference to the economic well-being of the country is not sufficient to justify the failure of the State to safeguard an applicant's rights under Article 8. In *Berrehab v. Netherlands* (judgment of 21 June 1988, Series A no. 138), for example, the Court found that the actions of the authorities could not be justified by the alleged economic well-being of the Netherlands. In *López Ostra* (cited above), too, the Court held, after examining the Government's argument, that "... the State did not succeed in striking a fair balance between the interests of the town's economic well-being ...and the applicant's effective enjoyment of her right to respect for her home and her private and family life" (p. 56, § 58).

17. Although we might agree with the judgment when it states: "the Court must consider whether the State can be said to have struck a fair balance between those interests [namely, the economic interests of the country] and the conflicting interests of the persons affected by noise disturbances" (see paragraph 122 of the judgment), the fair balance between the rights of the applicants and the interests of the broader community must be maintained. The margin of appreciation of the State is narrowed because of the fundamental nature of the right to sleep, which may be outweighed only by the real, pressing (if not urgent) needs of the State. Incidentally, the Court's own subsidiary role, reflected in the use of the "margin of appreciation", is itself becoming more and more marginal when it comes to such constellations as the relationship between the protection of the right to sleep as an aspect of privacy and health on the one hand and the very general economic interest on the other hand.

18. As stated above, reasons based on economic arguments referring to "the country as a whole" without any "specific indications of the economic cost of eliminating specific night flights" (see paragraph 126 of the judgment) are not sufficient. Moreover, it has not been demonstrated by the

respondent State how and to what extent the economic situation would in fact deteriorate if a more drastic scheme – aimed at limiting night flights, halving their number or even halting them – were implemented.

IV. Realistic assessment under Article 41

19. Finally, and in view of the powers of the Court under Article 41 and the alleged importance of the macroeconomic interests at stake, indemnification of the "small minority" should be less of a problem rather than more. The applicants' rights could have been treated much more realistically than they were by the majority. In other words, the issue could have been circumscribed to the "small minority's" entitlement to just satisfaction for the real pecuniary and non-pecuniary damage incurred. Since we do not believe that the "subjective element" referred to in paragraph 118 of the judgment is simply a euphemism for "capricious hyper-sensitivity", the applicants in our opinion ought to have been awarded just satisfaction.

DISSENTING OPINION OF JUDGE Sir Brian KERR

In *Christine Goodwin v. the United Kingdom* ([GC], no. 28957/95, § 113, ECHR 2002-VI), the Grand Chamber held that "Article 13 cannot be interpreted as requiring a remedy against the state of domestic law, as otherwise the Court would be imposing on Contracting States a requirement to incorporate the Convention". That ruling relates to the "state of domestic law", and seems to me to go beyond the traditional view that Article 13 does not guarantee a remedy against "legislation" (as in, for example, *James and Others v. the United Kingdom*, judgment of 21 February 1986, Series A no. 98, p. 47, § 85). It corresponds closely to the ideas I expressed on Article 13 in my dissenting opinion to the Chamber's judgment of 2 October 2001.

I would here wish simply to record that it is my view, given the nature of the applicants' complaints, the state of domestic law at the time and the role of Article 13 in the Convention structure, that there has been no violation of Article 13 in this case.

World Health Organization

REGIONAL OFFICE FOR Europe

ENVIRONMENTAL NOISE GUIDELINES for the European Region

Abstract

Noise is an important public health issue. It has negative impacts on human health and well-being and is a growing concern. The WHO Regional Office for Europe has developed these guidelines, based on the growing understanding of these health impacts of exposure to environmental noise. The main purpose of these guidelines is to provide recommendations for protecting human health from exposure to environmental noise originating from various sources: transportation (road traffic, railway and aircraft) noise, wind turbine noise and leisure noise. They provide robust public health advice underpinned by evidence, which is essential to drive policy action that will protect communities from the adverse effects of noise. The guidelines are published by the WHO Regional Office for Europe. In terms of their health implications, the recommended exposure levels can be considered applicable in other regions and suitable for a global audience.

Keyword

NOISE – ADVERSE EFFECTS, PREVENTION AND CONTROL

ENVIRONMENTAL EXPOSURE – ADVERSE EFFECTS, PREVENTION AND CONTROL

GUIDELINES

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REGIONAL OFFICE FOR Europe

Environmental Noise Guidelines for the European Region

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Foreword

Noise is one of the most important environmental risks to health and continues to be a growing concern among policy-makers and the public alike. Based on the assessment threshold specified in the Environmental Noise Directive of the European Union (EU), at least 100 million people in the EU are affected by road traffic noise, and in western Europe alone at least 1.6 million healthy years of life are lost as a result of road traffic noise.

At the request of Member States at the Fifth Ministerial Conference on Environment and Health in Parma, Italy, in March 2010, the WHO Regional Office for Europe has developed these guidelines, based on the growing understanding of the health impacts of exposure to environmental noise. They provide robust public health advice, which is essential to drive policy action that will protect communities from the adverse effects of noise.

These WHO guidelines – the first of their kind globally – provide recommendations for protecting human health from exposure to environmental noise originating from various sources. They not only offer robust public health advice but also serve as a solid basis for future updates, given the growing recognition of the problem and the rapid advances in research on the health impacts of noise. The comprehensive process of developing the guidelines has followed a rigorous methodology; their recommendations are based on systematic reviews of evidence that consider more health outcomes of noise exposure than ever before. Through their potential to influence urban, transport and energy policies, these guidelines contribute to the 2030 Agenda for Sustainable Development and support WHO's vision of creating resilient communities and supportive environments in the European Region.

Following the publication of WHO's community noise guidelines in 1999 and night noise guidelines for Europe in 2009, these latest guidelines represent the next evolutionary step, taking advantage of the growing diversity and quality standards in this research domain. Comprehensive and robust, and underpinned by evidence, they will serve as a sound basis for action. While these guidelines focus on the WHO European Region and provide policy guidance to Member States that is compatible with the noise indicators used in the EU's Environmental Noise Directive, they still have global relevance. Indeed, a large body of the evidence underpinning the recommendations was derived not only from noise effect studies in Europe but also from research in other parts of the world – mainly in Asia, Australia and the United States of America.

I am proud to present these guidelines as another leading example of the normative work undertaken in our Region in the area of environment and health. On behalf of the WHO Regional Office for Europe and our European Centre for Environment and Health in Bonn, Germany, which coordinated the development of the guidelines, I would like to express my gratitude to the large network of experts, partners, colleagues and consultants who have contributed to this excellent publication. I would also like to thank Switzerland and Germany for providing financial support to this complex project, and look forward to following the influence of the guidelines on policy and research in the years to come.

Dr Zsuzsanna Jakab

WHO Regional Director for Europe

Acknowledgements

The WHO Regional Office for Europe thanks all members of the Steering Group, Guideline Development Group, Systematic Review Team and External Review Group for their invaluable contributions in the guidelines development process.

The WHO Regional Office for Europe, through its European Centre for Environment and Health, coordinated the development of these guidelines. The project was coordinated by Marie-Eve Héroux and Dorota Jarosinska, under the overall supervision of Elizabet Paunovic, Head of the European Centre for Environment and Health.

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Abbreviations

%HA	percentage of the population "highly annoyed"
%HSD	percentage of the population "highly sleep-disturbed"
BMI	body mass index
CI	confidence interval
CNG	WHO guidelines for community noise
DALY	disability-adjusted life-year
dB	decibel
DW	disability weight
EC	European Commission
EEA	European Environment Agency
END	European Union Directive 2002/49/EC relating to the assessment and management of environmental noise (Environmental Noise Directive)
ERF	exposure–response function
EU	European Union
GDG	Guideline Development Group
GRADE	Grading of Recommendations Assessment Development and Evaluation
ICBEN	International Commission on Biological Effects of Noise
IHD	ischaemic heart disease
JRC	Joint Research Centre [of the European Commission]
mmHg	milimeters of mercury
NNG	WHO night noise guidelines for Europe
OR	odds ratio
PECCOS	population, exposure, comparator, confounder, outcome and study [framework]
PICOS	population, intervention, comparator, outcome and study [framework]
PLD	personal listening device
RANCH	Road traffic and aircraft noise exposure and children's cognition and health [study]
RCT	randomized control trial
RR	relative risk
SCENIHR	Scientific Committee on Emerging and Newly Identified Hazards and Risk

Glossary of acoustic terms

A-weighting	A frequency-dependent correction that is applied to a measured or calculated sound of moderate intensity to mimic the varying sensitivity of the ear to sound for different frequencies
C-weighting	A frequency-dependent correction that is applied to a measured or calculated sound of moderate intensity to mimic the varying sensitivity of the ear to sound for different frequencies – C-weighting is usually used for peak measurements
FAST	Fast response has a time constant of 125 milliseconds on a sound level meter
$L_{Aeq,T}$	A-weighted, equivalent continuous sound pressure level during a stated time interval starting at t_1 and ending at t_2, expressed in decibels (dB), at a given point in space[1]
$L_{A,max}$	Maximum time-weighted and A-weighted sound pressure level within a stated time interval starting at t_1 and ending at t_2, expressed in dB[1]
L_{AF}	A-weighted sound pressure level with FAST time constant as specified in IEC 61672-1[1]
$L_{AF,max}$	Maximum time-weighted and A-weighted sound pressure level with FAST time constant within a stated time interval starting at t_1 and ending at t_2, expressed in dB
$L_{AS,max}$	Maximum time-weighted and A-weighted sound pressure level with SLOW time constant within a stated time interval starting at t_1 and ending at t_2, expressed in dB
L_E	Sound energy density level is the logarithmic ratio of the time-averaged sound energy per unit volume to the reference sound energy density Eo = 10-12 J/m^3.
$L_{ex,8h}$	L_{eq} (equivalent continuous sound level) corrected for the length of the working shift, in this case 8 hours
L_{day}	Equivalent continuous sound pressure level when the reference time interval is the day[1]
L_{den}	Day-evening-night-weighted sound pressure level as defined in section 3.6.4 of ISO 1996-1:2016[1]
L_{dn}	Day-night-weighted sound pressure level as defined in section 3.6.4 of ISO 1996-1:2016[1]
$L_{evening}$	Equivalent continuous sound pressure level when the reference time interval is the evening[1]

[1] *Source*: ISO (2016).

L_{night}	Equivalent continuous sound pressure level when the reference time interval is the night[1]
$L_{peak,C}$	Level of peak sound pressure with C-weighting, within a specified time interval
$L_{peak,lin}$	Level of peak sound pressure with linear frequency weighting, within a specified time interval
Sound pressure level	the logarithm of the ratio of a given sound pressure to the reference sound pressure in dB is 20 times the logarithm to the base ten of the ratio.
SLOW	Slow response has a time constant of 10 000 milliseconds on a sound level meter

Executive summary

Environmental noise is an important public health issue, featuring among the top environmental risks to health. It has negative impacts on human health and well-being and is a growing concern among both the general public and policy-makers in Europe.

At the Fifth Ministerial Conference on Environment and Health in Parma, Italy, in 2010, WHO was requested by the Member States in the European Region to produce noise guidelines that included not only transportation noise sources but also personal electronic devices, toys and wind turbines, which had not yet been considered in existing guidelines. Furthermore, European Union Directive 2002/49/EC relating to the assessment and management of environmental noise (END) and related technical guidance from the European Environment Agency both elaborated on the issue of environmental noise and the importance of up-to-date noise guidelines.

The WHO Regional Office for Europe has therefore developed environmental noise guidelines for the European Region, proposing an updated set of public health recommendations on exposure to environmental noise.

Objectives

The main purpose of these guidelines is to provide recommendations for protecting human health from exposure to environmental noise originating from various sources: transportation (road traffic, railway and aircraft) noise, wind turbine noise and leisure noise. Leisure noise in this context refers to all noise sources that people are exposed to due to leisure activities, such as attending nightclubs, pubs, fitness classes, live sporting events, concerts or live music venues and listening to loud music through personal listening devices. The guidelines focus on the WHO European Region and provide policy guidance to Member States that is compatible with the noise indicators used in the European Union's END.

The following two key questions identify the issues addressed by the guidelines.

- In the general population exposed to environmental noise, what is the exposure–response relationship between exposure to environmental noise (reported as various indicators) and the proportion of people with a validated measure of health outcome, when adjusted for confounders?
- In the general population exposed to environmental noise, are interventions effective in reducing exposure to and/or health outcomes from environmental noise?

In light of these questions, the guidelines set out to define recommended exposure levels for environmental noise in order to protect population health.

Methods used to develop the guidelines

The process of developing the WHO guidelines followed a rigorous methodology involving several groups with separate roles and responsibilities. Throughout the process, the Grading of

Recommendations Assessment, Development and Evaluation (GRADE) approach was followed. In particular, the different steps in the development of the guidelines included:

- formulation of the scope and key questions of the guidelines;
- review of the pertinent literature;
- selection of priority health outcome measures;
- a systematic review of the evidence;
- assessment of certainty of the bodies of evidence resulting from systematic reviews;
- identification of guideline exposure levels; and
- setting of the strength of recommendations.

Based on the defined scope and key questions, these guidelines reviewed the pertinent literature in order to incorporate significant research undertaken in the area of environmental noise and health since the community noise guidelines and night noise guidelines for Europe were issued (WHO, 1999; WHO Regional Office for Europe, 2009). In total, eight systematic reviews of evidence were conducted to assess the relationship between environmental noise and the following health outcomes: cardiovascular and metabolic effects; annoyance; effects on sleep; cognitive impairment; hearing impairment and tinnitus; adverse birth outcomes; and quality of life, mental health and well-being. A separate systematic review of evidence was conducted to assess the effectiveness of environmental noise interventions in reducing exposure and associated impacts on health.[2] Once identified and synthesized, the quality of the evidence of the systematic reviews was assessed by the Systematic Review Team. Subsequently, the Guideline Development Group (GDG) formulated recommendations, guided by the Systematic Review Team's assessment and informed by of a number of additional contextual parameters. To facilitate the formulation of recommendations, the GDG first defined priority health outcomes and then selected the most relevant health outcome measures for the outcomes. Consecutively, a process was developed to identify the guideline exposure levels with the help of the exposure–response functions provided by the systematic reviews. To reflect the nature of the research (observational studies) underpinning the relationship between environmental noise and health, the GRADE procedures were adapted to the requirements of environmental exposure studies where needed.

Noise indicators

From a scientific point of view, the best noise indicator is the one that performs best in predicting the effect of interest. There are, however, a number of additional criteria that may influence the choice of indicator. For example, various indicators might be suitable for different health end-points. Some considerations of a more political nature can be found in the European Commision's Position paper on EU noise indicators (EC, 2000).

[2] All systematic reviews are publicly available online in the *International Journal of Environmental Research and Public Health*. A detailed list of links to the individual reviews is provided in section 2.3.2 and in Annex 2 of these guidelines.

The current guidelines are intended to be suitable for policy-making in the WHO European Region. They therefore focus on the most used noise indicators L_{den} and/or L_{night} (see the glossary of acoustic terms for further details). They can be constructed using their components (L_{day}, $L_{evening}$, L_{night} and the duration in hours of L_{night}), and are provided for exposure at the most exposed façade, outdoors. The L_{den} and L_{night} indicators are those generally reported by authorities and are widely used for exposure assessment in health effect studies.

Recommendations

Specific recommendations have been formulated for road traffic noise, railway noise, aircraft noise, wind turbine noise and leisure noise. Recommendations are rated as either strong or conditional.

Strength of recommendation

- A **strong** recommendation can be adopted as policy in most situations. The guideline is based on the confidence that the desirable effects of adherence to the recommendation outweigh the undesirable consequences. The quality of evidence for a net benefit – combined with information about the values, preferences and resources – inform this recommendation, which should be implemented in most circumstances.
- A **conditional** recommendation requires a policy-making process with substantial debate and involvement of various stakeholders. There is less certainty of its efficacy owing to lower quality of evidence of a net benefit, opposing values and preferences of individuals and populations affected or the high resource implications of the recommendation, meaning there may be circumstances or settings in which it will not apply.

Alongside specific recommendations, several guiding principles were developed to provide generic advice and support for the incorporation of recommendations into a policy framework. They apply to the implementation of all of the specific recommendations.

Guiding principles: reduce, promote, coordinate and involve

- Reduce exposure to noise, while conserving quiet areas.
- Promote interventions to reduce exposure to noise and improve health.
- Coordinate approaches to control noise sources and other environmental health risks.
- Inform and involve communities potentially affected by a change in noise exposure.

The recommendations, source by source, are as follows.

Road traffic noise

Recommendation	Strength
For average noise exposure, the GDG strongly recommends reducing noise levels produced by road traffic below **53 decibels (dB)** L_{den}, as road traffic noise above this level is associated with adverse health effects.	Strong
For night noise exposure, the GDG strongly recommends reducing noise levels produced by road traffic during night time below **45 dB** L_{night}, as night-time road traffic noise above this level is associated with adverse effects on sleep.	Strong
To reduce health effects, the GDG strongly recommends that policy-makers implement suitable measures to reduce noise exposure from road traffic in the population exposed to levels above the guideline values for average and night noise exposure. For specific interventions, the GDG recommends reducing noise both at the source and on the route between the source and the affected population by changes in infrastructure.	Strong

Railway noise

Recommendation	Strength
For average noise exposure, the GDG strongly recommends reducing noise levels produced by railway traffic below **54 dB** L_{den}, as railway noise above this level is associated with adverse health effects.	Strong
For night noise exposure, the GDG strongly recommends reducing noise levels produced by railway traffic during night time below **44 dB** L_{night}, as night-time railway noise above this level is associated with adverse effects on sleep.	Strong
To reduce health effects, the GDG strongly recommends that policy-makers implement suitable measures to reduce noise exposure from railways in the population exposed to levels above the guideline values for average and night noise exposure. There is, however, insufficient evidence to recommend one type of intervention over another.	Strong

Aircraft noise

Recommendation	Strength
For average noise exposure, the GDG strongly recommends reducing noise levels produced by aircraft below **45 dB** L_{den}, as aircraft noise above this level is associated with adverse health effects.	Strong
For night noise exposure, the GDG strongly recommends reducing noise levels produced by aircraft during night time below **40 dB** L_{night}, as night-time aircraft noise above this level is associated with adverse effects on sleep.	Strong
To reduce health effects, the GDG strongly recommends that policy-makers implement suitable measures to reduce noise exposure from aircraft in the population exposed to levels above the guideline values for average and night noise exposure. For specific interventions the GDG recommends implementing suitable changes in infrastructure.	Strong

Wind turbine noise

Recommendation	Strength
For average noise exposure, the GDG conditionally recommends reducing noise levels produced by wind turbines below **45 dB** L_{den}, as wind turbine noise above this level is associated with adverse health effects.	Conditional
No recommendation is made for average night noise exposure L_{night} of wind turbines. The quality of evidence of night-time exposure to wind turbine noise is too low to allow a recommendation.	
To reduce health effects, the GDG conditionally recommends that policy-makers implement suitable measures to reduce noise exposure from wind turbines in the population exposed to levels above the guideline values for average noise exposure. No evidence is available, however, to facilitate the recommendation of one particular type of intervention over another.	Conditional

Leisure noise

Recommendation	Strength
For average noise exposure, the GDG conditionally recommends reducing the yearly average from all leisure noise sources combined to **70 dB** $L_{Aeq,24h}$ as leisure noise above this level is associated with adverse health effects. The equal energy principle[3] can be used to derive exposure limits for other time averages, which might be more practical in regulatory processes.	Conditional
For single-event and impulse noise exposures, the GDG conditionally recommends following existing guidelines and legal regulations to limit the risk of increases in hearing impairment from leisure noise in both children and adults.	Conditional
Following a precautionary approach, to reduce possible health effects, the GDG strongly recommends that policy-makers take action to prevent exposure above the guideline values for average noise and single-event and impulse noise exposures. This is particularly relevant as a large number of people may be exposed to and at risk of hearing impairment through the use of personal listening devices. There is insufficient evidence, however, to recommend one type of intervention over another.	Strong

Target audience

The guidelines are published by the WHO Regional Office for Europe. In terms of their health implications, the recommended exposure levels can be considered applicable in other regions and suitable for a global audience, as a large body of the evidence underpinning the recommendations was derived not only from European noise effect studies but also from research in other parts of the world – mainly in America, Asia and Australia.

[3] The equal energy principle states that the total effect of sound is proportional to the total amount of sound energy received by the ear, irrespective of the distribution of that energy in time (WHO, 1999).

1. Introduction

Environmental noise features among the top environmental risks to physical and mental health and well-being, with a substantial associated burden of disease in Europe (WHO Regional Office for Europe & JRC, 2011; Hänninen et al., 2014). It has negative impacts on human health and well-being and is a growing concern among both the general public and policy-makers in Europe.

WHO published community noise guidelines (CNG) and night noise guidelines (NNG) for Europe in 1999 and 2009, respectively (WHO, 1999; WHO Regional Office for Europe, 2009). Since then, significant new evidence has accumulated on the health effects of environmental noise.

The need for updated health-based guidelines originates in part from commitments made at the Fifth Ministerial Conference on Environment and Health in Parma, Italy, in 2010, where Member States asked WHO to produce appropriate noise guidelines that would include additional noise sources such as personal electronic devices, toys and wind turbines (WHO Regional Office for Europe, 2010). Furthermore, European Union (EU) Directive 2002/49/EC relating to the assessment and management of environmental noise (the END – EC, 2002a) and related technical guidance from the European Environment Agency (EEA) both elaborated on the issue of environmental noise and the importance of up-to-date noise guidelines (EEA, 2010).

The WHO Regional Office for Europe has therefore developed environmental noise guidelines for the European Region, proposing an updated set of public health recommendations on exposure to environmental noise. The main purpose of these guidelines is to provide recommendations for protecting human health from exposure to environmental noise originating from various sources: transportation (road traffic, railway and aircraft) noise, wind turbine noise and leisure noise. The guidelines focus on the WHO European Region and provide policy guidance to Member States that is compatible with the noise indicators used in the EU's END.

The following two key questions identify the issues addressed by the guidelines.

- In the general population exposed to environmental noise, what is the exposure–response relationship between exposure to environmental noise (reported as various indicators) and the proportion of people with a validated measure of health outcome, when adjusted for confounders?
- In the general population exposed to environmental noise, are interventions effective in reducing exposure to and/or health outcomes from environmental noise?

1.1 The public health burden from environmental noise

Exposure to noise can lead to auditory and nonauditory effects on health. Through direct injury to the auditory system, noise leads to auditory effects such as hearing loss and tinnitus. Noise is also a nonspecific stressor that has been shown to have an adverse effect on human health, especially following long-term exposure. These effects are the result of psychological and physiological distress, as well as a disturbance of the organism's homeostasis and increasing allostatic load (Basner et al., 2014). This is further outlined in the WHO narrative review of the biological mechanisms of nonauditory effects (Eriksson et al., 2018).

The evidence of the association between noise exposure and health effects is based on experimental work regarding biological plausibility and, in observational studies, consistency among study results, presence of an exposure–response relationship and the magnitude of the effect. Environmental noise risk assessment and risk management relies on established exposure–response relationships (Babisch, 2014).

In 2011 the WHO Regional Office for Europe and the European Commission (EC) Joint Research Centre (JRC) published a report on the burden of disease from environmental noise that quantified the healthy years of life lost in western Europeam countries as a result of environmental noise (WHO Regional Office for Europe & JRC, 2011). The burden of disease is calculated, in a single measure of disability-adjusted life-years (DALYs), as the sum of the years of life lost from premature mortality and the years lived with disability for people living with the disease or health condition or its consequences in the general population (WHO, 2014a).

Sufficient information was deemed available to quantify the burden of disease from environmental noise for cardiovascular disease, cognitive impairment in children, sleep disturbance, tinnitus and annoyance. The report, based on a limited set of data, estimated that DALYs lost from environmental noise in western European countries are equivalent to 61 000 years for ischaemic heart disease (IHD), 45 000 years for cognitive impairment in children, 903 000 years for sleep disturbance, 22 000 years for tinnitus and 654 000 years for annoyance (WHO Regional Office for Europe & JRC, 2011). These results indicate that at least one million healthy years of life are lost every year from traffic-related environmental noise in western Europe. Sleep disturbance and annoyance, mostly related to road traffic noise, constitute the bulk of this burden. Available assessments place the burden of disease from environmental noise as the second highest after air pollution (WHO Regional Office for Europe & JRC, 2011; Hänninen et al., 2014; WHO 2014b). However, a lack of noise exposure data in the central and eastern parts of the WHO European Region means that it is not possible to assess the burden of disease from environmental noise for the whole Region.

1.2 The environmental noise policy context in the EU

The EU has been working to develop a harmonized noise policy for more than two decades. 1993 saw the start of the EC's Fifth Environment Action Programme, which stated that "no person should be exposed to noise levels which endanger health and quality of life" (EC, 1993). This was followed by a Green Paper on future noise policy (EC, 1996), which reinforced the importance of noise as one of the main environmental problems in Europe and proposed a new framework for noise policy development.

The Sixth Environment Action Programme had as one of its objectives: "to achieve a quality of environment where the levels of man-made contaminants do not give rise to significant impacts on, or risks to, human health" (EC, 2002b). This paved the way for the Commission to adopt and implement the END in 2002 (EC, 2002a). The main aim of the Directive is "to define a common approach intended to avoid, prevent or reduce on a prioritized basis the harmful effects, including annoyance, due to exposure to environmental noise".

The END obliges the EC to adapt its Annexes I–III (I on noise indicators in addition to L_{den}[4] and L_{night}[5], II on noise assessment methods and III on methods for assessing harmful effects of noise) to technical and scientific progress. While work on revising Annex II was finalized in 2015 and common noise assessment methods were introduced (EC, 2015), revisions of Annex III to establish methods to assess the harmful effects of noise only started in 2015. Annex III would primarily define what exposure–response relationships should be used to assess the effect of noise on populations. EU Member States have already expressed the view that the recommendations from these environmental noise guidelines for the WHO European Region will guide the revision of Annex III. Beside this main directive, few other legislative documents cover different noise sources and other related issues in the EU (EEA, 2014: Annex I).

The Seventh Environment Action Programme, which guides European environment policy until 2020 (EC, 2014a), is committed to safeguarding the EU's citizens from environment-related risks to health by ensuring that by 2020 "noise pollution in the Union has significantly decreased, moving closer to WHO-recommended levels". A particular requirement for achieving this is "implementing an updated EU noise policy aligned with the latest scientific knowledge, and measures to reduce noise at source, and including improvements in city design".

In addition to the EU's END, several national governments also have legislation and/or limit values that apply at national and/or regional levels (WHO Regional Office for Europe, 2012). The EEA, through its European Topic Centre on Land Use and Spatial Information, gathers noise exposure data and maintains the Noise Observation and Information Service for Europe, based on strategic noise maps provided by Member States (EEA, 2018). A total of 33 EEA countries, in addition to six cooperating countries in south-eastern Europe, report information on noise exposure to the EEA, following the requirements of the END. The quality and availability of noise exposure assessment differs between EU and non-EU Member States where, even if noise legislation has been harmonized with the Directive, noise mapping and action plans are still at the planning stage (EEA, 2014; 2017a; WHO Regional Office for Europe, 2012).

1.2.1 Definition of indicators in the END

The END specifies a number of noise indicators to be applied by Member States in noise mapping and action planning. The most important are L_{den} and L_{night}.

The L_{den} indicator is an average sound pressure level over all days, evenings and nights in a year (EEA, 2010). This compound indicator was adopted by the EU in the END (EC, 2002a). The L_{den} in decibels (dB) is defined by a specific formula, where:

- L_{day} is the A-weighted long-term average sound level as defined in ISO 1996-1: 2016, determined over all the day periods of a year;
- $L_{evening}$ is the A-weighted long-term average sound level as defined in ISO 1996-1: 2016, determined over all the evening periods of a year; and
- L_{night} is the A-weighted long-term average sound level as defined in ISO 1996-1: 2016, determined over all the night periods of a year (ISO, 2016).

[4] Day-evening-night-weighted sound pressure level as defined in section 3.6.4 of ISO 1996-1:20161 (ISO, 2016).

[5] Equivalent continuous sound pressure level when the reference time interval is the night.

The L_{night}, according to the definition in the END, is an equivalent outdoor sound pressure level, measured at the most exposed façade, associated with a particular type of noise source during night time (at least eight hours), calculated over a period of a year (WHO Regional Office for Europe, 2009).

Annex I of the END gives technical definitions for L_{den} and L_{night}, as well as supplementary noise indicators, which might be useful for monitoring special noise situations. For example, in the case of noisy but short-lived noise like shooting noise or noise emitted by trains, $L_{A,max}$ is often used. This is a measure of the maximum sound pressure reached during a defined measurement period. It is used to set noise limits and is sometimes considered in studies to determine certain health effects (such as awakening reactions).

1.3 Perceptions of environmental noise in the WHO European Region

1.3.1 Trends at the regional level

The general population greatly values the benefits of clean and quiet environments. In Europe, people perceive noise as an important issue that affects human health and well-being (EC, 2008; 2014b). In recent years, several Europe-wide surveys have examined the perception of noise as an issue among the population. Overall, these surveys ask about generic noise, referring to "neighbourhood noise" or "noise from the street". This type of noise differs significantly in its definition from what is considered "environmental noise" in these guidelines. Nevertheless, in the absence of specific large surveys on perceptions of environmental noise as defined in these guidelines, the results provide insight into the public perception of this issue.

The European quality-of-life surveys, carried out every four years, are unique, pan-European surveys examining both the objective circumstances of lives of European citizens and how they feel about those circumstances and their lives in general. The last (fourth) survey was conducted in 2016–2017, involving nearly 37 000 citizens from all EU Member States and the five candidate countries (Albania, Montenegro, Serbia, the former Yugoslav Republic of Macedonia and Turkey). Respondents were asked whether they had major, moderate or no problems with noise in the immediate neighbourhood of their home. Almost one third (32%) reported problems with noise (ranging from 14% to 51% in individual countries), mainly in cities or city suburbs (49%) (Eurofound, 2017).

A 2010 survey of the then 27 countries in the EU, requested by the EC, showed that 80% of respondents (n = 26 602) believed that noise affects their health, either to some or to a great extent (EC, 2010).

A Eurobarometer report on attitudes of European citizens towards the environment (EC, 2014b) compiled opinions on various environmental risks from almost 28 000 respondents in 28 EU countries. Results showed that for 15% of respondents, noise pollution is one of the top five environmental issues they are worried about. Furthermore, 17% of respondents said that they lack information about noise pollution.

1.3.2 Trends at the national level

Data on perception of specific sources of environmental noise as a problem are not available for the entire WHO European Region. Nevertheless, some countries – including France, Germany, the Netherlands, Slovakia and the United Kingdom – conduct national surveys on noise annoyance, either regularly or on demand (Sobotova et al., 2006; Lambert & Philipps-Bertin, 2008; van Poll et al., 2011; Centraal Bureau voor de Statistiek, 2012; Notley et al., 2014; Umweltbundesamt, 2017).

According to these large-scale surveys, road traffic noise is the most important source of annoyance, generally followed closely by neighbour noise. Aircraft noise can also be a substantial source of annoyance. Railway noise and industrial noise are enumerated less frequently. Only limited data are available on the population's perception of newer sources of noise, such as wind turbines.

While perception surveys do not provide information on actual quantitative relationships between noise exposure and health outcomes, it is important to note that the results of such surveys represent people's preferences and values regarding environmental noise. Despite limitations and an incomplete picture, the available data on perception of environmental noise as a public health problem show concern in Europe. People are not always aware of the health impacts of noise, especially of those related to long-term noise exposure at lower levels. Greater awareness of the issue may further increase positive values and preferences.

1.4 Target audience

The environmental noise guidelines for the European Region serve as a reference for an audience made up of different groups, with varied areas of expertise including decision-making, research and advocacy. More specifically, this covers:

- various technical experts and decision-makers at the local, national or international levels, with responsibility for developing and implementing regulations and standards for noise control, urban planning and housing, and other relevant environment and health domains;
- health impact assessment and environmental impact assessment practitioners and researchers;
- national and local authorities responsible for developing and implementing relevant measures and for risk communication;
- nongovernmental organizations and other advocacy groups involved in risk communication and general awareness-raising.

These guidelines are published by the WHO Regional Office for Europe. In terms of their health implications, the recommended exposure levels can be considered applicable in other regions and suitable for a global audience, as a large body of the evidence underpinning the recommendations was derived not only from European noise effect studies but also from research in other parts of the world – mainly in America, Asia and Australia.

2. Development of the guidelines

2.1 Overview

The process of developing WHO guidelines follows a rigorous methodology and involves several groups with well defined roles and responsibilities (WHO, 2014c). These include: formulation of the scope and key questions of the guidelines; review of the pertinent literature; selection of priority health outcome measures; a systematic review of the evidence; an assessment of certainty of the bodies of evidence resulting from systematic reviews; identification of guideline exposure levels; and setting of the strength of recommendations. Throughout the process, the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach was followed (Morgan et al., 2016).

The development of environmental noise guidelines started in 2013. Following WHO's procedures, the WHO Regional Office for Europe, through its European Centre for Environment and Health in Bonn, Germany, obtained planning approval and established a Steering Group and a Guideline Development Group (GDG). The former was primarily involved in initiating, structuring and executing the guideline development process; the latter was composed of leading experts and end-users, responsible for the process of scoping the guidelines and developing the evidence-based recommendations. During the initiation meeting in October 2013 in Bonn, the GDG members defined the scope of the guidelines, decided on the key questions to be addressed, prioritized health outcomes and set a timeline for completion of the work. Furthermore, authors were appointed for background papers, systematic reviews and different guideline background chapters.

In October 2014 a main evidence review meeting was held between the GDG and the Systematic Review Team in Bern, Switzerland, to discuss the evidence review drafts. In October 2014 and May 2015 the GDG met in Bern and Bonn, respectively, to refine the scope and draft recommendations. The revision and finalization of the systematic reviews of evidence was completed in early 2017. Through a series of remote meetings and teleconferences, the GDG discussed and addressed the remaining outstanding issues and feedback from the peer review of the draft guidelines, and decided on the final formulation of the recommendations. The following sections describe the steps of the guideline development process in detail.

2.2 Scope of the guidelines

Defining the scope of the guidelines included the selection of noise sources to be considered, as well as situations in which people are exposed, and noise indicators used for the formulation of recommendations. These guidelines separately consider outdoor exposure to environmental noise from road traffic, railway traffic, aircraft, wind turbines as well as outdoor and indoor exposure during leisure activities (such as attending nightclubs, pubs, fitness classes, live sporting events, concerts or live music venues and listening to loud music through personal listening devices). The guidelines are source specific and not environment specific. They therefore cover all settings where people spend a significant portion of their time, such as residences, educational institutions, workplaces and public venues, although hospital noise is exempted from the list of public institutions owing to the unique characteristics of the population involved.

The GDG agreed not to develop specific recommendations for occupational and industrial noise. Industrial noise can affect both people working at an industrial site and those living in its vicinity. The guidelines do not consider workers' exposure to noise in industrial environments, as these are regulated by workplace standards and may, in some cases, require the wearing of protective equipment or application of other preventive and protective measures. Further, the guidelines do not explicitly consider industrial noise as an environmental noise source, affecting people living in the vicinities of industrial sites. This is mainly due to the large heterogeneity and specific features of industrial noise, and the fact that exposure to industrial noise has a very localized character in the urban population.

Likewise, the current guidelines do not provide specific recommendations for the prevention of health effects linked to neighbourhood noise. Neighbourhood noise may stem from various potential sources of noise (such as ventilation systems; church bells; animals; neighbours; commercial, recreational and occupational activities; or shooting/military). As the sources may be located in close proximity to where people live, they can cause considerable concern even at low levels (Omlin et al., 2011). Several of these sources can also produce low-frequency noise, and as such, require indoor measurements for proper exposure assessment. In general, little scientific research is available on exposure and health outcomes related to neighbourhood noise.

Moreover, the guidelines do not include recommendations about any kind of multiple exposures. In everyday life people are often exposed to noise from several sources at the same time. In Germany, for example, 44% of the population are annoyed by at least two and up to five sources of noise (Umweltbundesamt, 2015). For some health outcomes, such as obesity, new evidence indicates that combined exposure to noise from several means of transportation is particularly harmful (Pyko et al., 2015; 2017).

Research indicates that, alongside exposure to more than one source of noise, combined exposure to different factors – for example, noise and vibration or noise and air pollution – has gained increasing relevance in recent years (Sörensen et al., 2017). The EC estimates that the social cost of noise and air pollution is up to €1 trillion every year (EC, 2016a). WHO acknowledges the need to develop comprehensive models to quantify the effects of multiple exposures on human health. As the main body of evidence on environmental noise still focuses on source-specific impacts of noise on health outcomes and does not incorporate combined exposure effects of multiple noise sources or other pollutants, however, the current guidelines provide recommendations for each source of noise specifically. No attempt has been made to combine noise from multiple sources for any particular health outcome.

2.2.1 Key questions

The environmental noise guidelines for the WHO European Region seek to address two main questions, which define the issues addressed by the guideline recommendations.

- In the general population exposed to environmental noise, what is the exposure–response relationship between exposure to environmental noise (reported as various indicators) and the proportion of people with a validated measure of health outcome, when adjusted for confounders?
- In the general population exposed to environmental noise, are interventions effective in reducing exposure to and/or health outcomes from environmental noise?

2.2.2 Environmental noise indicators used in the guidelines

From a scientific point of view, the best noise indicator is the one that performs best in predicting the effect of interest. There are, however, a number of additional criteria that may influence the choice of indicator because, for example, various indicators might be suitable for different health end-points and some indicators are more practical to use or easier to calculate than others. Some of these considerations are of a more political nature, as mentioned in the EC's Position paper on EU noise indicators (EC, 2000).

The current guidelines are intended to be suitable for policy-making primarily in the WHO European Region. They are therefore based on the most frequently used average noise indicators in Europe: L_{den} and L_{night}. These are often reported by authorities and are used widely for exposure assessment in health effect studies and noise impact assessments in the Region. The L_{den} (also referred to as "DENL") indicator can be calculated as the A-weighted average sound pressure level, measured over a 24-hour period, with a 10 dB penalty added to the average level in the night (23:00–07:00 or 22:00–06:00), a 5 dB penalty added to the evening (19:00–23:00 or 18:00–22:00) and no penalty added to the daytime period (07:00–19:00 or 06:00–18:00). The penalties are introduced to indicate people's extra sensitivity to noise during the evening and night. The L_{night} indicator is the A-weighted average sound pressure level, measured over an eight-hour period during night time, usually between 23:00 and 07:00 (EC, 2002a).

In these guidelines, L_{den} and L_{night} refer to a measurement or calculation of noise exposure at the most exposed façade, outdoors, reflecting the long-term average exposure. Thus, L_{den} and L_{night} represent all the single noise events due to a specific noise source that occur over a longer period of time, such as during a year. Moreover, most health outcomes considered in these guidelines are expected to occur as a result of long-term exposure. It is generally accepted that the most relevant parts of the whole day or night, which especially account for the time when a person is at home, are correctly attributed when using average indicators like L_{den} or L_{night}.

The majority of studies that form the body of evidence for the recommendations in these guidelines – among them large-scale epidemiological studies and socioacoustic surveys on annoyance and self-reported sleep disturbance – refer to noise exposure measured outdoors, usually at the most exposed façade of dwellings. Virtually all noise exposure prediction models in use today estimate free-field exposure levels outdoors, and most noise abatement regulations refer to outdoor levels as well. These are the practical reasons why the GDG decided not to recommend any guideline values for noise indoors. Nevertheless, in certain cases it could be helpful to estimate indoor levels based on outdoor values. The differences between indoor and outdoor levels are usually estimated at around 10 dB for open, 15 dB for tilted or half-open and about 25 dB for closed windows. When considering more accurate estimation of indoor levels, using a range of different predictors, the relevant scientific literature can be consulted (Locher et al., 2018).

The GDG was aware of the fact that many countries outside the EU are not bound by the terms of the END (EC, 2002a) and/or use noise indicators other than L_{den} or L_{night} in their noise regulations. They still can make use of these guidelines, however, because energy-based average noise indicators are usually highly correlated and "rule of thumb" transformations from one indicator to another are possible with acceptable uncertainty, as long as the conversion accounts for the long-term average of populations, rather than individual exposure situations. Empirically derived generic conversion terms between a wide range of different noise indicators (including L_{den}, L_{dn}, L_{day}, L_{night} and $L_{Aeq,24h}$; see the glossary of acoustic terms for further details), with their uncertainty estimates, were published recently (Brink et al., 2018). The GDG encourages the use of these conversions, should the need arise.

In many situations, average noise levels like the L_{den} or L_{night} indicators may not be the best to explain a particular noise effect. Single-event noise indicators – such as the maximum sound pressure level ($L_{A,max}$)[6] and its frequency distribution – are warranted in specific situations, such as in the context of night-time railway or aircraft noise events that can clearly elicit awakenings and other physiological reactions that are mostly determined by $L_{A,max}$. Nevertheless, the assessment of the relationship between different types of single-event noise indicators and long-term health outcomes at the population level remains tentative. The guidelines therefore make no recommendations for single-event noise indicators.

Different noise sources – for example, road traffic noise and railway noise – can be characterized by different spectra, different noise level rise times of noise events, different temporal distributions of noise events and different frequency distributions of maximum levels. Because of the extensive differences in the characteristics of individual noise sources, these guidelines only consider source-specific exposure–response functions (ERFs) and, therefore, formulate only source-specific recommendations.

2.3 Evidence base

Based on the overall scope and key questions the current guidelines review the relevant literature in the area of environmental noise and health in order to incorporate significant research undertaken since the publication of previous guidelines. The process of evidence search and retrieval involved several steps. These include the identification, retrieval and synthesis of the evidence, followed by a systematic review and assessment (described in section 2.4).

2.3.1 Identification, retrieval and synthesis of evidence

As a first step, the GDG identified key health outcomes associated with environmental noise. Next, it rated the relevance of these health outcomes according to the following three categories:

- critical for assessing environmental noise issues
- important, but not critical for assessing environmental noise issues
- unimportant.

The GDG rated the relevance based on the seriousness and prevalence of the outcomes and the anticipated availability of evidence for an association with noise exposure. The following health outcomes were selected as either critical or important for developing recommendations on the health impacts of environmental noise.

[6] $L_{A,max}$ is the maximum time-weighted and A-weighted sound pressure level within a stated time interval starting at t1 and ending at t2, expressed in dB.

Critical health outcome	Important health outcome
Cardiovascular disease	Adverse birth outcomes
Annoyance[7]	Quality of life, well-being and mental health
Effects on sleep	Metabolic outcomes
Cognitive impairment	
Hearing impairment and tinnitus	

The GDG noted that research into the relationship between noise exposure and its effects on humans brings into focus several questions concerning the definition of health and the boundary between normal social reaction to noise and noise-induced ill health. As stated in WHO's Constitution: "Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (WHO, 1946). Accordingly, documenting physical health does not present a complete picture of general health; and being undisturbed by noise in all activities, including sleep, constitutes an asset worthy of protection. Therefore, in accordance with the above definition, the GDG regarded (long-term) annoyance and impaired well-being, as well as self-reported sleep disturbance due to noise, as health outcomes.

Regarding sleep disturbance, the health outcome measures considered in these guidelines largely disregard "objective" indicators of sleep disturbance, such as the probability of awakening reactions or other polysomnography parameters. The main reason for this is the nature of the body of evidence on acute, objectively measured effects of noise during sleep. Studies of physiological effects of sleep and especially polysomnographic investigations are complex and resource-demanding; they therefore include only a small number of participants, who are often healthy young volunteers not representative of the general population. For these reasons, the majority of such studies do not meet the requirements for inclusion in the GRADE framework and full-scale meta-analysis, including adjustment for confounders. Furthermore, it is currently unclear how acute physiological reactions that affect the microstructure of sleep but are less well correlated with global sleep parameters, such as total sleep time, are related to long-term health impediments, especially considering the large interindividual differences in susceptibility to noise (Basner et al., 2011).

As sleeping satisfies a basic need and the absence of undisturbed sleep can have serious effects on human health (WHO Regional Office for Europe, 2009), the GDG set self-reported sleep disturbance, in line with the WHO definition of health, as a primary health outcome. Even though self-reported sleep disturbance might differ considerably from objectively measured parameters of sleep physiology, it constitutes a valid indicator in its own right, as it reflects the effects on sleep perceived by an individual over a longer period of time (WHO Regional Office for Europe & JRC, 2011). The importance of considering both annoyance and self-reported sleep disturbance as health outcomes is further supported by evidence indicating that they may be part of the causal pathway of noise-induced cardiovascular and metabolic diseases. This is further elaborated in the narrative review on biological mechanisms (Eriksson et al., 2018).

[7] Noise annoyance is defined as a feeling of displeasure, nuisance, disturbance or irritation caused by a specific sound (Ouis, 2001). In the current guidelines, "annoyance" refers to long-term noise annoyance.

The second step in the evidence retrieval process constituted formulation of the key questions for the critical and important health outcomes and identification of the areas of evidence to be reviewed, following the PICOS/PECCOS approach defined in the WHO handbook for guideline development (WHO, 2014c). PICOS/PECCOS is an evidence-based technique that frames health care-related questions to facilitate the search for suitable studies that can provide answers to the questions at hand (Huang et al., 2006). The PICOS approach divides intervention questions into five elements: population, intervention, comparator, outcome and study design. In exposure studies, PICOS becomes PECCOS, which stands for population, exposure, comparator, confounder, outcome and study design. The specification of the elements of PICOS/PECCOS serves to construct the body of evidence that underpins each recommendation. Due to the complex nature of environmental noise, several distinct areas of evidence were defined to address each of the scoping questions comprehensively.

For each of the critical and important health outcomes a systematic review was conducted (see also section 2.3.2). Health outcomes regarded as important were given less weight in the decision-making process than critical ones. Inclusion and exclusion criteria to be regarded in the systematic evidence reviews were defined in accordance with the PICOS/PECCOS framework for the evaluation of evidence (see Table 1). All evidence that met the inclusion criteria was included in the systematic reviewing process. A detailed description of the types of measure for each of the health outcomes under consideration is provided in the protocol for conducting the systematic reviews (Héroux & Verbeek, 2018a). See Annex 2 for details of all background documents and systematic reviews used in preparation of these guidelines.

Table 1. Inclusion and exclusion criteria for evidence reviews of health effects of environmental noise

Category	Inclusion criteria	Exclusion criteria
Populations	• Members of the general population • Specific segments of the population particularly at risk (children or vulnerable groups) • People exposed to noise in occupational settings (if relevant with combined exposure to environmental noise)	• Does not meet inclusion criteria
Exposure	• Noise exposure levels, either measured or calculated and expressed in dB values • Representative of the individual exposure of study participants (for most observational studies the dwelling location or home) • Calculated levels for transportation noise (road, rail, air) based on traffic data reflecting the use of roads, railway lines and in- and outbound flight routes at airports	• Does not meet inclusion criteria; in particular: - studies using hearing loss or hearing impairment as a proxy for (previous) noise exposure - surveys assessing noise exposure or number of listening hours based on subjective ratings given by subjects in a questionnaire
Confounders	• No inclusion criteria applied since the relationship between exposure to noise and a health outcome can be confounded by other risk factors; however, possible confounders taken into account were assessed for every study	• No exclusion criteria applied; however, possible confounders taken into account were assessed for every study

⇨

Table 1. contd.

Category	Inclusion criteria	Exclusion criteria
Outcomes	• Adverse birth outcomes • Annoyance • Cardiovascular disease • Cognitive impairment • Effects on sleep • Hearing impairment and tinnitus • Metabolic outcomes • Quality of life, mental health and well-being	• Does not meet inclusion criteria
Study types	• Cohort studies • Case-control studies • Cross-sectional studies • Ecological studies (only for cardiovascular disease)	• Does not meet inclusion criteria

Alongside the systematic reviews of the critical and important health outcomes, the GDG decided to review the evidence on health effects from noise mitigation measures and interventions to reduce noise levels in order to inform and complement the recommendations.

Interventions on environmental noise were defined according to five broad categories based on the available intervention literature and the experience of decades of environmental noise management (see Table 2 and Brown & van Kamp, 2017).

Table 2. Types of noise intervention

Intervention type	Intervention category	Intervention subcategory
A	Source intervention	• change in emission levels of sources • time restrictions on source operations
B	Path intervention	• change in the path between source and receiver • path control through insulation of receiver/receiver's dwelling
C	New/closed infrastructure	• opening of a new infrastructure noise source • closure of an existing one • planning controls between (new) receivers and sources
D	Other physical intervention	• change in other physical dimensions of dwelling/neighbourhood
E	Behaviour change intervention	• change in individual behaviour to reduce exposure • avoidance or duration of exposure • community education, communication

The GDG recognized that nonacoustic factors are an important possible confounder in both ERFs between noise levels and critical health effects and the effects of acoustic interventions on health outcomes. Whereas the inclusion criteria for confounders were not specified in PECCOS for the systematic reviews of evidence, they were considered at the stage of assessing the quality of evidence, using the GRADE approach. Depending on the health effect under investigation, possible nonacoustic factors may include:

- gender
- age
- education
- subjective noise sensitivity
- extroversion/introversion
- general stress score
- co-morbidity
- length of residence
- duration of stay at dwelling in the day
- window orientation of a bedroom or living room towards the street
- personal evaluation of the source
- attitudes towards the noise source
- coping capacity with respect to noise
- perception of malfeasance by the authorities responsible
- body mass index
- smoking habits.

In noise annoyance studies nonacoustic factors may explain up to 33% of the variance (Guski, 1999). The higher the quality of evidence, the lower confounding effects of nonacoustic factors may be expected. Nevertheless, as with measurement errors, confounding cannot be avoided.

Based on the retrieval and evaluation of the pertinent literature, the GDG decided to address the association of environmental noise from different sources and health outcomes separately and individually for each source of noise, and for critical and important health outcomes.

In addition to the systematic reviews of the health effects of environmental noise, a narrative review of biological mechanisms of nonauditory effects was conducted (Eriksson et al., 2018). This covers literature related to pathways for nonauditory effects and provides supporting evidence on the association between environmental noise and health outcomes in humans, especially related to cardiovascular and metabolic diseases.

2.3.2 Systematic reviewing process

After the retrieval of the evidence based on the PICOS/PECCOS approach, systematic reviews were conducted for all critical and important health outcomes. To meet the demands of the diverse and broad nature of the evidence, it was agreed that systematic reviews could vary in type. For some areas of evidence, a novel and fully fledged systematic reviewing process was needed to summarize the existing evidence; for others, the reviewing process could build upon existing (and mostly published) systematic reviews and summaries of evidence. Thus, the process consisted of two phases.

First, a comprehensive search was conducted for available systematic reviews and meta-analyses on environmental noise effects published after 2000. Each of the reviews was assessed for both relevance and quality. To be included in the evidence review process, studies from these reviews were required to meet a high quality standard, judged according to high scores of the AMSTAR checklist.[8] In cases where quality criteria were met but the review was older than two years (published before 2012), the search of the systematic review was updated to include new papers. If no good quality systematic reviews were available, a new search for original papers was conducted. The Systematic Review Team decided how the results would affect the search strategy for individual studies as part of the second phase. This was based on the assessment of the quality of the systematic reviews and on the coherence between the main research questions of the systematic reviews and the scope of the work of the guidelines.

In the second phase a search for individual papers was conducted, with the search strategy adapted according to the outcome of the first phase. As availability of systematic reviews and meta-analyses differed for the various health outcomes considered in the guidelines, this process varied for each evidence review. The search included cohort studies, case-control studies and cross-sectional studies of people exposed to environmental noise. Where relevant – for example, for the health outcome cardiovascular disease – the search also included ecological studies.

Due to the individualized retrieval of evidence for each of the systematic reviews, the time frames of the literature included varied. An indication of the temporal coverage of the studies included in different systematic review is provided in the relevant tables in Chapter 4.

A detailed description of the methodology used to conduct the systematic evidence reviews, including individual protocols for the reviews of health effects resulting from environmental noise and from noise interventions, is available (Héroux & Verbeek, 2018b). Furthermore, all systematic reviews conducted in the guideline development process are publicly available in the open-access journal *International Journal of Environmental Research and Public Health*:

- systematic review of transport noise interventions and their impacts on health (Brown & van Kamp, 2017);
- systematic review on environmental noise and adverse birth outcomes (Nieuwenhuijsen et al, 2017);
- systematic review on environmental noise and annoyance (Guski et al., 2017);
- systematic review on environmental noise and cardiovascular and metabolic effects (van Kempen et al., 2018);
- systematic review on environmental noise and cognition (Clark & Paunovic, 2018);
- systematic review on environmental noise and effects on sleep (Basner & McGuire, 2018);
- systematic review on environmental noise and permanent hearing loss and tinnitus (Śliwińska-Kowalska & Zaborowski, 2017);
- systematic review on mental health and well-being (Clark & Paunovic, in press).

[8] AMSTAR is an instrument used to assess quality of evidence; it stands for "A MeaSurement Tool to Assess systematic Reviews" (Shea et al., 2007).

2.4 From evidence to recommendations

Once the evidence had been identified and synthesized, the Systematic Review Team assessed its quality. Subsequently, the GDG formulated recommendations, guided by this assessment and consideration of a number of other factors recognized as important. To facilitate the formulation of recommendations, it first prioritized the health outcome measures of the critical and important outcomes. A process was developed to identify the guideline exposure levels from each of the ERFs provided by the systematic reviews of evidence.

The following sections describe the assessment of the overall quality of the evidence based on the GRADE approach, selection of priority health outcome measurements, identification of guideline exposure levels and setting the strength of recommendations.

2.4.1 Assessment of overall quality of a body of evidence: the GRADE approach

As set out in the WHO handbook for guideline development (WHO, 2014c), the main framework for producing evidence-informed recommendations is the GRADE approach (Guyatt et al., 2008). This is used to assess the quality of a body of evidence synthesized in a systematic review. The assessment facilitates judgements about the certainty of effect estimates, which increases with the quality of the body of evidence. The quality can be rated high, moderate, low or very low (see Box 1).

Box 1 GRADE interpretations of quality of evidence

- **High quality:** further research is very unlikely to change the certainty of the effect estimate
- **Moderate quality:** further research is likely to have an important impact on the certainty of the effect estimate and may change the estimate
- **Low quality:** further research is very likely to have an important impact on the certainty of the effect estimate and is likely to change the estimate
- **Very low quality:** any effect estimate is uncertain

The original GRADE approach was developed specifically to rate the body of evidence resulting from a review of intervention studies. The initial quality level is set by study design: randomized control trials (RCTs) are considered high quality, whereas observational (nonrandomized) study designs are low quality. Then five factors are considered for downgrading the quality of the body of evidence resulting from RCTs or observational studies, and three factors are considered for upgrading the body of evidence resulting from observational studies alone.

The following five factors are used for downgrading the quality of evidence by one or two levels:

- study limitations or risk of bias in all studies that make up the body of evidence
- inconsistency of results between studies
- indirectness of evidence in the studies
- imprecision of the pooled effect estimate
- publication bias detected in a body of evidence.

The following three factors are used for upgrading the quality of evidence:

- high magnitude of the pooled effect
- direction of residual confounding and biases opposes an effect (i.e. when all plausible confounders are anticipated to reduce the estimated effect and there is still a significant effect)
- exposure–response gradient.

The GRADE approach was originally developed for application in the field of clinical medicine, where the majority of studies are randomized trials. However, to assess health effects resulting from an exposure such as environmental noise, randomized controlled trials are not applicable, as it would be unethical to expose participants deliberately to possibly harmful risk factors. The limitations of the application of GRADE to environmental health have been recognized and discussed in the literature (Morgan et al., 2016). Other types of study design dominate the evidence base in the domain of environmental noise research, so it was necessary to adapt the original GRADE approach to the subject of the current guidelines, as follows.

Instead of using the RCT study design as the starting-point for the quality rating, the study design most applicable and available for the field of research at hand was used. Thus, for evidence on the association between noise exposure and clinical health outcome measures, the rating of an evidence base consisting of cohort and case-control studies[9] was initially rated high quality. Cross-sectional studies and ecological studies were rated low quality and very low quality, respectively. This initial point of departure was only adapted for the evidence of the association between noise exposure and annoyance and sleep disturbance. Here, cross-sectional studies were rated high quality because annoyance and sleep disturbance are regarded as an immediate effect of exposure to environmental noise. Finally, in accordance with the original GRADE approach, the starting-point for evidence on the effect of interventions was rated low quality for observational studies. After determining the point of departure, the evidence base was rated down or up whenever one or more of the criteria for downgrading or upgrading (described above) were met. Each of the systematic reviews commissioned for these guidelines includes a detailed report on the assessment of the quality of the evidence.

A detailed discussion of the adaptations of GRADE is provided in the separate methodology publication (Héroux & Verbeek, 2018b).

2.4.2 Selection of priority health outcomes

In line with the WHO handbook for guideline development (WHO, 2014c), the GDG selected the key health outcomes associated with environmental noise at the beginning of the evidence retrieval process, and the systematic reviews were commissioned accordingly. The selection of health outcomes was based on the available evidence for the association between environmental noise and the specific outcome, as well as public concern about the health outcome resulting from noise exposure. The following health outcomes were rated critical: cardiovascular disease, annoyance,

[9] In the context of the current guidelines, "cohort studies" refer to longitudinal studies in which the occurrence of the outcome of interest in an exposed group is compared to the occurrence of that outcome in a reference group with no or lower exposure over time.

effects on sleep, cognitive impairment and hearing impairment and tinnitus. Adverse birth outcomes, quality of life, well-being and mental health, and metabolic outcomes were rated important (see also section 2.3.1).

Since all these health outcomes can be measured in various ways, the GDG evaluated each individually and prioritized different outcome measures for each in terms of their representativeness and validity. These measures were used to derive the guideline exposure levels; their prioritization was based on the impact of the disease and the disability weights (DWs) associated with the health outcome measure.[10]

The critical health outcomes, priority outcome measures identified and justifications for their selection are listed in Table 3.

Table 3. Critical health outcomes, outcome measures identified and justifications for selection

Critical health outcome	Critical health outcome measures (priority measures marked in bold)	Justification for selection
Cardiovascular disease (L_{den})	Self-reported or measured prevalence, **incidence**, hospital admission or mortality due to: • **ischaemic heart disease (IHD) (including angina pectoris and/or myocardial infarction)** • **hypertension** • stroke	Except for self-reports, these are objective measures of the outcome, affect a large proportion of the population, have important health consequences and can lead to more severe diseases and/or mortality. DW for IHD: 0.405. DW for hypertension: 0.117.
Effects on sleep (L_{night})	• **percentage of the population highly sleep-disturbed (%HSD)**, self-reported, assessed with a standardized scale • polysomnography measured outcomes (probability of additional awakenings) • cardiac and blood pressure outcome measures during sleep • motility measured sleep outcomes in adults • sleep disturbance in children	This is the most meaningful, policy-relevant measure of this health outcome. Self-reported sleep disturbances are a very common problem in the general population: they affect quality of life directly and may also lead to subsequent health impediments. Effects on sleep may be in the causal pathway to cardiovascular disease. This measure is not a proxy for physiological sleep quality parameters but is an important outcome in its own right. DW for %HSD: 0.07.
Annoyance (L_{den})	• **percentage of the population highly annoyed (%HA), assessed with standardized scale** • percentage annoyed, preferably assessed with standardized scale	This is the most objective measure of this health outcome. Large proportions of the population are affected by noise annoyance, even at relatively low exposure levels. Annoyance may be in the causal pathway to cardiovascular disease. DW for %HA: 0.02.

[10] DWs are ratings that vary between 0 and 1, in which 0 indicates no disability and 1 indicates the maximum amount of disability. The rates are derived from large population surveys in which people are asked to rank a specific disease for its impact on several abilities. The DWs have been proven useful in calculating the burden of disease.

Table 3. contd.

Critical health outcome	Critical health outcome measures (priority measures marked in bold)	Justification for selection
Cognitive impairment (L_{den})	• **reading and oral comprehension, assessed with tests** • impairment assessed with standardized tests • short and long-term memory deficit • attention deficit • executive function deficit (working memory capacity)	This outcome measure is the most meaningful: it can affect vulnerable individuals (children) and have a significant impact later in life. DW for impaired reading and oral comprehension: 0.006.
Hearing impairment and tinnitus (L_{Aeq}[11] and $L_{AF,max}$[12])	• **permanent hearing impairment, measured by audiometry** • permanent tinnitus	This outcome measure can affect vulnerable individuals (children) and have a significant impact later in life. It is the most objective measure for which there is an ISO standard (ISO, 2013), specifying how to estimate noise-induced hearing loss. DW for mild severity level (threshold at 25 dB) for childhood onset: 0.0150.

Table 4 provides a list of the important health outcomes along with the corresponding health outcome measures included in the systematic reviews. There was no prioritization of health outcome measures leading to justification of selection, since important health outcomes had less impact on the development of recommendations.

Table 4. Important health outcomes and health outcome measures reviewed

Important health outcome	Health outcome measures reviewed
Adverse birth outcomes (L_{den})	• pre-term delivery • low birth weight • congenital anomalies
Quality of life, well-being and mental health (L_{den})	• self-reported health and quality of life • medication intake for depression and anxiety • self-reported depression, anxiety and psychological distress • interviewer-assessed depressive and anxiety disorders • emotional and conduct disorders in children • children's hyperactivity • other mental health outcomes
Metabolic outcomes (L_{den})	prevalence, incidence, hospital admission or mortality due to: • type 2 diabetes • obesity

[11] L_{Aeq} is an A-weighted, equivalent continuous sound pressure level during a stated time interval starting at t1 and ending at t2, expressed in dB, of a noise at a given point in space.

[12] $L_{AF,max}$ is the maximum time-weighted and A-weighted sound pressure level with FAST time constant within a stated time interval starting at t1 and ending at t2, expressed in dB.

2.4.3 Identification of guideline exposure levels for each noise source

The GDG agreed to set guideline exposure levels based on the definition: "noise exposure levels above which the GDG is confident that there is an increased risk of adverse health effects". The identification of guideline values for each of the specific noise sources involved five distinct steps:

1. assessment of the validity of ERFs resulting from the systematic reviews of the effects of noise on each of the critical and important health outcomes;
2. assessment of the lowest noise level measured in the studies included in each of the corresponding systematic reviews;
3. assessment of the smallest risk or relative risk (RR) increase for each of the adverse health outcomes considered relevant;
4. determination of the guideline exposure level based on the ERF, starting from the lowest level measured (see step 2) and associated with the smallest relevant risk increase for adverse health outcomes (see step 3);
5. comparison of the guideline exposure levels calculated for each of the critical health outcomes of one source (for example, incidence of IHD, incidence of hypertension, %HA, permanent hearing impairment and reading and oral comprehension for road traffic noise): selection of the guideline exposure level for each noise source was based on the priority health outcome measure with the lowest exposure level for that source.

To define an "increased risk" to set the guideline exposure level, the GDG made a judgement about the smallest risk or RR of the adverse health effect it considered relevant for each of the priority health outcome measures. It is important to note that the relevant risk increases are benchmark values. The GDG agreed to set them in accordance with the guiding principles it had developed, to provide guideline values that illustrate an increased risk of adverse health effects. It used expert judgements for the determination of the benchmark values; these are elaborated further in section 2.4.3.2.

The guideline exposure levels presented are therefore not meant to identify effect thresholds (the lowest observed adverse effect levels for different health outcomes). This is a difference in approach from prior WHO guidelines, like the night noise guidelines for Europe (WHO Regional Office for Europe, 2009), which explicitly aimed to define levels indicating no adverse health effects. The approach to making choices about relevant risk increases is outlined below and summarized in Table 5.

For IHD and hypertension, RR increases were considered; for annoyance and sleep disturbance, absolute risks of %HA and %HSD were considered; and for reading and oral comprehension an average delay of reading age was defined. For the cardiovascular outcomes, incidence measures were prioritized, although much of the epidemiological evidence was based on prevalence data – particularly for hypertension – where almost no longitudinal studies were available. Prevalence data are generally derived from cross-sectional studies, where the temporal aspects are difficult to determine.

Table 5. Priority health outcomes and relevant risk increases for setting guideline levels

Priority health outcome measure (associated DW)	Relevant risk increase considered for setting of guideline level
Incidence of IHD (DW: 0.405)	5% RR increase
Incidence of hypertension (DW: 0.117)	10% RR increase
%HA (DW: 0.02)	10% absolute risk
%HSD (DW: 0.07)	3% absolute risk
Permanent hearing impairment (DW: 0.0150)	No risk increase due to environmental noise
Reading and oral comprehension (DW: 0.006)	One-month delay in terms of reading age

The DWs used to rank the priority critical health outcomes measures were retrieved from the relevant literature. For cardiovascular disease as a group and for hypertension, the burden of disease from environmental noise values (WHO Regional Office for Europe & JRC, 2011) were not considered applicable by the GDG for these guidelines. Thus, for cardiovascular disease, the DW value (DW: 0.405) specifically applied to acute myocardial infarction in the publication outlining the data sources, methods and results of the global burden of disease in 2002 (Mathers et al., 2003) was retained. Since hypertension is mainly viewed as an important risk factor and not as a health outcome, no general DW has been developed. The only other available DW value available is the DW of 0.117 for hypertensive episodes in pregnancy (Mathers et al., 1999). In the absence of any general DW, the GDG agreed on a conservative approach and decided to use this value.

The DWs for high sleep disturbance (DW: 0.07), high annoyance (DW: 0.02) and impaired reading and oral comprehension (DW: 0.006) were developed in the context of calculating the burden of disease from environmental noise (WHO Regional Office for Europe & JRC, 2011). The DW for hearing impairment was not included in that publication, but it was available from the technical paper on the burden of disease from environmental noise (WHO, 2013); the DW for permanent hearing impairment ranged from 0.0031 to 0.3342, depending on severity level. Environmental noise (leisure noise) contributes to the cumulative total noise exposure throughout the life-course, which may lead to permanent hearing impairment and cause more severe disability in the later years of life. As a result, the GDG selected a DW of 0.0150 for moderate severity level ("has difficulty following a conversation in a noisy environment, but no other hearing problems"). For cognitive impairment, the DW was derived from the estimates of the burden of disease from environmental noise (WHO Regional Office for Europe & JRC, 2011). This was at a very conservative value (DW: 0.006) for noise-related impairment of children's cognition, equivalent to a DW for contemporaneous cognitive deficit in the context of a range of cognitive impairments in children ranging from 0.468 for Japanese encephalitis to 0.024 for iron deficiency anaemia (Lopez et al., 2006).

2.4.3.1 Development of ERFs

The systematic reviews of evidence provided either an ERF or other noise exposure value/metric that could be related to a risk increase of the health outcome measure. These ERFs were used to develop guideline exposure levels; however, only those functions where noise exposure demonstrated a statistically significant effect were used.

To obtain the starting level of the ERFs derived in the systematic reviews, a weighted average of the lowest exposure values measured in the individual studies included in the meta-analyses was calculated. The weighting used the inverse of the variance of the effect estimate of the study. Thus, the lowest exposure value of studies with a small variance (usually with the largest sample size) contributed the most to the assumed onset of the ERF.

2.4.3.2 Relevant risk increase of adverse health effects

The following sections describe in detail the rationale for the selection of the relevant relative risk (RR) increase percentage for each of the priority health outcome measures considered.

Cardiovascular disease: IHD and hypertension

High-quality epidemiological evidence described in the systematic review on cardiovascular and metabolic effects of environmental noise indicates that exposure to road traffic noise increases the risk of IHD (van Kempen et al., 2018). The GDG was confident that health risks result from exposure at an RR increase in the order of 5–10% in the incidence of IHD. This is similar to the reasoning in the WHO air quality guidelines for fine particulate matter ($PM_{2.5}$) (WHO, 2006). To determine a relevant risk increase for IHD, the GDG took as a starting-point the RR increase of 5% measured in epidemiological studies of environmental noise or air pollution. Taking into account the incidence of IHD and the seriousness of the disease, it considered lowering the RR increase for IHD to 1%, as a 5% RR increase might imply a comparatively high absolute risk from a population perspective. To decide on the final benchmark value for IHD, several aspects were considered: the number of people in a population affected by IHD; whether health risks caused by noise would make up a large part of the incidence of the disease; other examples of health risks of similar magnitude leading to preventive action. For IHD, in an average EU country with 20 million inhabitants, an RR increase of 5% for IHD would lead to several thousand extra cases attributable to noise yearly. This corresponds to a proportion of cases of IHD attributable to noise exposure of less than 10%, which is still relatively small. After extensive discussion at the very end of the guideline development process, the GDG decided to adhere to 5% as the relevant risk increase.

Hypertension is a common condition and is an important risk indicator for IHD and other cardiovascular diseases. Thus, the hypertension risk increase can be transformed into a risk increase for cardiovascular disease. To derive a relevant risk increase, the GDG focused on the incidence of hypertension, owing to the nature and quality of epidemiological evidence. Since hypertension is less serious than IHD, and not all people with hypertension will progress to cardiovascular disease, the relevant risk increase in the incidence of hypertension needed to be higher than that for IHD. Therefore, the GDG agreed on an RR increase of 10% for hypertension.

Self-reported sleep disturbance and annoyance

The GDG initially considered 5%HSD and 10%HA due to noise as relevant absolute risks, not be exceeded at the guideline level. After discussion, however, members agreed that these absolute risks were too large, since a considerable proportion of the population would still be affected; they decided to lower the relevant risk from 5% being highly sleep-disturbed to 3%. In doing so, the GDG referred to the WHO night noise guidelines (WHO, 2009), which concluded that while there was insufficient evidence that physiological effects at noise levels below 40 dB L_{night} are harmful to health, there were observed adverse health effects at levels starting from 40 dB L_{night}. At 40 dB, about 3–4%

(depending on the noise source) of the population still reported being highly sleep-disturbed due to noise, which was considered relevant to health. The GDG considered it important that this level is consistent with the previous health-based approach adopted by the WHO night noise guidelines, and agreed that the absolute risk associated with the guideline value selected should not exceed 3%HSD to be health protective.

For annoyance, which is considered a less serious health effect than self-reported sleep disturbance (as indicated by the respective DWs), the relevant risk remained at 10%HA. This means the absolute risk associated with the guideline value selected should be closest to, but not above 10%HA, to be health protective.

Cognitive impairment: reading and oral comprehension

Acquiring skills in reading and oral comprehension at a young age is important for further development: a delay in acquiring these skills can have an impact later in life (Wilson & Lonigan, 2010). This impact cannot be predicted very accurately, but the GDG considered a delay of one month a relevant absolute risk.

Permanent hearing impairment

The literature on hearing impairment as a result of occupational noise exposure is extensive. A noise exposure level beyond 80 dB during 40 years of working a 40 hour work week can give rise to permanent hearing impairment. Given that environmental exposure to noise is much lower than these levels and that noise-related hearing impairments are not reversible, the GDG considered that there should be no risk of hearing impairment due to environmental noise and considered any increased risk of hearing impairment relevant.

2.4.4 Strength of the recommendations

Finally, having determined the guideline exposure levels based on the ranking of prioritized health outcome measures, setting the strength of the recommendation was set as the final step of the guideline development process. This was also guided by the GRADE methodology (Alonso-Coello et al., 2016a; 2016b). According to this approach, strength of recommendation can be set as either strong or conditional (WHO, 2014c).

- A **strong** recommendation can be adopted as policy in most situations. The guideline is based on the confidence that the desirable effects of adherence to the recommendation outweigh the undesirable consequences. The quality of evidence for a net benefit – combined with information about the values, preferences and resources – inform this recommendation, which should be implemented in most circumstances.
- A **conditional** recommendation requires a policy-making process with substantial debate and involvement of various stakeholders. There is less certainty of its efficacy owing to lower quality of evidence of a net benefit, opposing values and preferences of individuals and populations affected or the high resource implications of the recommendation, meaning there may be circumstances or settings in which it will not apply.

The GRADE approach defines a number of parameters that should be assessed to determine the strength of recommendations: quality of evidence, balance of benefits and harms, values and preference related to the outcomes of interventions to exposure, resources implications, priority of the problem, equity and human rights, acceptability and feasibility (Box 2; Morgan et al., 2016).

Box 2 Parameters determining the strength of a recommendation

Quality of evidence further represents the confidence in the estimates of effect of the evaluated evidence, across outcomes critical and important to decision-making. The higher the quality of evidence, the greater the likelihood of a strong recommendation.

Balance of benefits and harms requires an evaluation of the absolute effects of both benefits and harms (or downsides) of the intervention or exposure and their importance. The greater net benefit or net harm associated with an intervention or an exposure, the greater the likelihood of a strong recommendation in favour or against an intervention or exposure.

Values and preferences related to the outcomes of an intervention or exposure set out the relative importance assigned to health outcomes by those affected by them; how such importance varies within and across populations; and whether this importance or variability is surrounded by uncertainty. The less uncertainty or variability there is about the values and preferences of people experiencing the critical or important outcomes, the greater the likelihood of a strong recommendation.

Resource implications take into consideration how resource-intensive and how cost-effective and substantially beneficial an intervention or exposure is. The more advantageous or clearly disadvantageous the resource implications are, the greater the likelihood of a strong recommendation either for or against the intervention or exposure.

The priority of the problem is determined by its importance and frequency (the burden of disease, disease prevalence or baseline risk). The greater the importance of the problem, the greater the likelihood of a strong recommendation.

Equity and human rights considerations are an important aspect of the process. The greater the likelihood that the intervention will reduce inequities, improve equity or contribute to the realization of one or several human rights as defined under the international legal framework, the greater the likelihood of a strong recommendation.

Acceptability plays a prominent role: the greater the acceptability of an option to all or most stakeholders, the greater the likelihood of a strong recommendation.

Feasibility overlaps with values and preferences, resource considerations, existing infrastructures, equity, cultural norms, legal frameworks and many other considerations. The greater the feasibility of an option from the standpoint of all or most stakeholders, the greater the likelihood of a strong recommendation.

The GDG evaluated the strength of the recommendations based on these parameters, following a two-step procedure. Initially, the strength of each recommendation was set as strong or conditional based on an assessment of the quality of evidence. The GDG then identified and assessed contextual parameters that might have a contributory role (see Box 2 above). Based on this qualitative evaluation, the initial recommendation strength was either adapted or confirmed. It is important to note that while the initial parameter "quality of evidence" was informed by comprehensive systematic reviewing processes, the remaining contextual parameters were assessed by the informed qualitative expert judgement of the GDG.

Furthermore, the GDG agreed to decision-making rules, applied when formulating the recommendations. An evidence rating of low quality or very low quality would lead only to a conditional recommendation. Setting a strong recommendation was only considered if the evidence was at least moderate quality. The final recommendations were formulated based on the consideration of all the parameters and decision rules adopted by the GDG. A detailed exploration of all the recommendations is set out in Chapter 3.

2.5 Individuals and partners involved in the guideline development process

The process of WHO guideline development is conducted by several groups with clearly defined roles and responsibilities. Comprising WHO staff members, experts and stakeholders, these are the Steering Group, the GDG, the Systematic Review Team and the External Review Group.

The **Steering Group** includes WHO staff members with different affiliations but whose work experience is relevant to the topic of environmental noise and associated health outcomes. It is involved at all stages of planning, selecting members of the GDG and External Review Group, reviewing evidence and developing potential recommendations at the main expert meetings, as well as ongoing consultation on revisions following peer review. Details of the members of the Steering Group are listed in Table A1.1 in Annex 1.

The **GDG** consists of a group of content experts gathered to investigate all aspects of evidence contributing to the recommendations, including expertise in evidence-based guideline development. This Group defined the key questions and priorities of the research, chose and ranked outcomes and provided advice on any modifications of the scope as established by the Steering Group. The members also outlined the systematic review methods; appraised the evidence used to inform the guidelines; and advised on the interpretation of this evidence, with explicit consideration of the overall balance of benefits and harms. Ultimately the GDG formulated the final recommendations, taking into account the diverse values and preferences of individuals and populations affected. It also determined the strength of the results and responded to external peer reviews. The complete list of GDG members and their specific roles, affiliations and areas of expertise are listed in Table A1.2 in Annex 1.

The **Systematic Review Team** includes experts in the field of environmental health, commissioned by WHO staff to undertake systematic reviews of evidence. The GDG recommended a number of authors to conduct the evidence reviews and summary chapters, based on their expertise. Details of the members of the Systtematic Review Team are included in Table A1.3 in Annex 1.

The **External Review Group** is composed of technical content experts and end-users as well as stakeholders, and is balanced geographically and by gender. The experts and end-users were selected for their expertise in the field, and the Group also included representatives of professional groups and industry associations, who will be implementing the guidelines. Members were asked to review the material at different stages of the development process. The list of technical experts and stakeholders is provided in Tables A1.4 and A1.5, respectively, in Annex 1.

Management of conflict of interest is an integral part of WHO's guideline development procedure. All members of the GDG and authors of the evidence reviews completed WHO declaration of interest forms. These were reviewed by the WHO Secretariat for potential conflicts of interest. A number of conflicts of interest were declared in the forms, but following a standardized management review it was not found necessary to exclude any members of the GDG or authors from their respective roles. Members of the External Review Group (technical experts only) were also asked to complete the form when invited to participate.

In addition, at the start of the meeting of the GDG all members of the GDG received a briefing about the nature of all types of conflict of interest (financial, academic/intellectual and nonacademic) and were asked to declare to the meeting any conflicts they might have. No member of the GDG or the Systematic Review Team was excluded from his/her respective role. A summary of the conflict of interest management is presented in Annex 3.

The GDG set its own rules on how it would work and how contentious issues should be resolved – for instance, by means of a vote. The main decision-making mechanism involved reaching consensus; if a vote was required, the experts involved in developing the underlying evidence for the specific recommendation were excluded from voting, and an agreement was reached via a two thirds majority of the rest of the group.

2.6 Previously published WHO guidelines on environmental noise

Prior to this publication, WHO published community noise guidelines (CNG) in 1999 (WHO, 1999) and night noise guidelines for Europe (NNG) in 2009 (WHO Regional Office for Europe, 2009).

2.6.1 CNG

The scope of WHO's efforts to develop the CNG in 1999 was similar to that for the current guidelines. The objective was then formulated as: "to consolidate scientific knowledge of the time on the health impacts of community noise and to provide guidance to environmental health authorities and professionals trying to protect people from the harmful effects of noise in nonindustrial environments" (WHO, 1999). The guidelines were based on studies carried out up to 1995 and a few meta-analyses from some years later.

The health risk to humans from exposure to environmental noise was evaluated and guideline values derived. At that time WHO had not yet developed its guideline development process, on which the current guidelines are based (WHO, 2014c). The main differences in content are that the previous guidelines were expert-based and provided more global coverage and applicability, such as issues of noise assessment and control that were addressed in detail. They included a discussion on noise sources and measurement, including the basic aspects of source characteristics, sound propagation and transmission. Adverse health effects of noise were characterized, and combined noise sources and their effects were considered. Furthermore, the guidelines included discussions of strategies and priorities in the management of indoor noise levels, noise policies and legislation, environmental noise impact and enforcement of regulatory standards; although there were no chapters on wind turbine noise and leisure noise.

2.6.2 NNG

In 2009 the WHO Regional Office for Europe published the NNG to provide scientifically based advice to Member States for the development of future legislation and policy action in the area of assessment and control of night noise exposure.

The NNG complement the previous CNG, incorporating the advancement of research on noise and sleep disturbance up to 2006. The working group of experts reviewed available scientific evidence on the health effects of night noise and derived health-based guideline values. Again, WHO had not yet introduced its evidence-based recommendations policy and the NNG were mainly expert-based. They considered the scientific evidence on the threshold of night noise exposure indicated by L_{night} as defined in the END (EC, 2002a), and the experts concluded that a L_{night} value of 40 dB should be the target of the NNG (for all sources) to protect the public, including the most vulnerable groups such as children, chronically ill and elderly people. Further, an L_{night} value of 55 dB was recommended as an interim target for countries that could not follow the guidelines in the short term for various reasons or where policy-makers chose to adopt a stepwise approach.

2.6.3 Differences from the prior noise guidelines

The current guidelines differ from the older ones, recommending levels of exposure unlike those previously outlined (especially by the NNG). The following major differences between the previous and current guidelines explain the novel set of recommended values.

- The development process for the current guidelines adhered to a new, rigorous, evidence-based methodology, as outlined in the WHO handbook for guideline development (WHO, 2014c). WHO adopted these internationally recognized standards to ensure high methodological quality and a transparent, evidence-based decision-making process in the guideline development.
- The current guidelines consider cardiovascular disease a critical health outcome measure.
- They also consider a broader set of health outcomes, including adverse birth outcomes, diabetes, obesity and mental well-being. Wherever applicable, incidence, prevalence and mortality were considered separately.
- The current guidelines cover two new noise sources: wind turbines and leisure noise.
- Critical and important health outcomes are considered separately for each of the noise sources.
- The guideline development process included the health effects of intervention measures to mitigate noise exposure from different noise sources for the first time.
- The style of recommendations differs: the current guidelines include an exact exposure value for every health outcome regarded as critical, for each noise source. Guideline recommendation values were set for each of the noise sources separately, based on the exact exposure values and a prioritization scheme, developed with the help of DWs.
- The current guidelines apply a 1 dB increment scheme, whereas prior guidelines (CNG and NNG) formulated or presented recommendations in 5 dB steps.

- In comparison to the 1999 CNG, which defined environment-specific exposure levels, the current guidelines are source specific. They recommend values for outdoor exposure to road traffic, railway, aircraft and wind turbine noise, and indoor as well as outdoor exposure levels for leisure noise.
- Except for leisure noise, all exposure levels recommended in the current guidelines are average sound pressure levels for outdoor exposure.
- The current guidelines make use of the noise indices defined in the END: L_{den} and L_{night}.

The definition of "community noise" used in the CNG in 1999 was also adapted. The GDG agreed to use the term "environmental noise" instead, and offered an operational definition of: "noise emitted from all sources except sources of occupational noise exposure in workplaces".

The current environmental noise guidelines for the European Region supersede the CNG from 1999. Nevertheless, the GDG recommends that all CNG indoor guideline values and any values not covered by the current guidelines (such as industrial noise and shopping areas) should remain valid.

Furthermore, the current guidelines complement the NNG from 2009. Two main aspects of the NNG constitute this complementarity: the different guiding principles and the comprehensive investigation of the immediate physiological effects of environmental noise on sleep. As guiding principles the NNG defined effect thresholds or "lowest observed adverse health effect levels" for both immediate physiological reactions during sleep (i.e. awakening reactions or body movements during sleep) and long-term adverse health effects (i.e. self-reported sleep disturbance). These guideline exposure levels defined a level below which no effects were expected to occur (corresponding to 30 dB L_{night}) and proceeded to define the level where adverse effects start to occur (corresponding to 40 dB L_{night}), with the aim of protecting the whole population, including – to some extent – vulnerable groups. The development of the NNG values relied on evidence-based expert judgement. In contrast, the current guidelines formulate recommendations more strictly based on the available evidence and following the guiding principle to identify exposure values based on a relevant risk increase of adverse health effects. Thus, the recommended guideline values might not lead to full protection of the population, including all vulnerable groups. The GDG stresses that the aim of the current guidelines is to define an exposure level at which effects certainly begin.

Secondly, the NNG comprehensively investigate the immediate short-term effects of environmental noise during sleep, including physiological reactions such as awakening reactions and body movements. They also provided threshold information about single-event noise indicators (such as the $L_{A,max}$). In contrast, the current guideline values for the night time are only based on the prevalence of self-reported sleep disturbance and do not take physiological effects into account. The causal link between immediate physiological reactions and long-term adverse health effects is complex and difficult to prove. Thus, the current guidelines are restricted to long-term health effects during night time and therefore only include recommendations about average noise indicators: L_{night}. Nevertheless, the evidence review on noise and sleep (Basner & McGuire, 2018) includes an overview of single-event exposure–effect relationships.

3. Recommendations

This chapter presents specific recommendations on guideline exposure levels and/or interventions to reduce exposure and/or improve health for individual sources of noise: road traffic, railway, aircraft, wind turbines and leisure noise. The strength of each recommendation is provided (strong or conditional) and a short rationale for how each of the guideline levels was achieved is given.

The GDG discussed extensively the best way to present guideline exposure levels – either as the exact values or in 5 dB steps – and the approach to rounding the values to the nearest integer. The 5 dB increment, rounded down from the exact exposure value to the nearest 5 dB level, was initially chosen as being commonly applied in noise legislation and used in prior guidelines (WHO, 1999; EC, 2002a; WHO Regional Office for Europe, 2009). It was also used to meet the principle of precaution, since imprecision in the exposure assessment in the field of epidemiology tends to attenuate the actual effects in the population.

Use of 5 dB increments resulted in uneven magnitude of rounding down, however, raising concerns of arbitrariness. It became apparent that inclusion of both exact values and the 5 dB rounded-down values might be confusing and could affect the applicability of the guidelines. Hence, the GDG ultimately decided that formulating recommendations based on the exact calculated values, rounded only to the nearest integer, would ensure more clarity and transparency. Furthermore, it noted that adhering to a 5 dB roster might not reflect the progress in the precision of exposure assessment methods in recent decades, which would justify application of a 1 dB step.

The GDG acknowledged that the recommendations might be presented as the exact guideline exposure levels only, leaving the use of 5 dB bands to the potential policy decisions to formulate or revise noise legislation, which are beyond the scope of this publication. The WHO guideline values are public health-oriented recommendations, based on scientific evidence on health effects and on an assessment of achievable noise levels. They are strongly recommended and as such should serve as the basis for a policy-making process in which policy options are quantified and discussed. It should be recognized that in that process additional considerations of costs, feasibility, values and preferences should also feature in decision-making when choosing reference values such as noise limits for a possible standard or legislation.

In addition to the source-specific recommendations in the following sections, a short rationale for the decision-making process by the GDG for developing a particular recommendation is provided, as well as an overview of the evidence considered. This includes a recapitulation of the specific PICOS/PECCOS question (see section 2.3.1), along with a summary of evidence for each of the critical and important health effects from exposure to each of the noise sources, and for the effectiveness of interventions.

Furthermore, a description is provided of the other factors considered according to the GRADE dimensions for the assessment of the strength of recommendations (see section 2.4.4). While the quality of evidence is central to determining this, the process of moving from evidence to recommendations involves several other considerations. These include values and preferences, balance of benefits and harms, consideration of the priority of the problem, resource implications, equity and human rights aspects, acceptability and feasibility (WHO, 2014c).

3.1 Road traffic noise

Recommendations

For average noise exposure, the GDG **strongly** recommends reducing noise levels produced by road traffic below **53 dB** L_{den}, as road traffic noise above this level is associated with adverse health effects.

For night noise exposure, the GDG **strongly** recommends reducing noise levels produced by road traffic during night time below **45 dB** L_{night}, as road traffic noise above this level is associated with adverse effects on sleep.

To reduce health effects, the GDG **strongly** recommends that policy-makers implement suitable measures to reduce noise exposure from road traffic in the population exposed to levels above the guideline values for average and night noise exposure. For specific interventions, the GDG recommends reducing noise both at the source and on the route between the source and the affected population by changes in infrastructure.

3.1.1 Rationale for the guideline levels for road traffic noise

The exposure levels were derived in accordance with the prioritization process of critical health outcomes described in section 2.4.3. For each of the outcomes, the exposure level was identified by applying the benchmark, set as relevant risk increase to the corresponding ERF. In the case of exposure to road traffic noise, the process can be summarized as follows (Table 6).

Table 6. Average exposure levels (L_{den}) for priority health outcomes from road traffic noise

Summary of priority health outcome evidence	Benchmark level	Evidence quality
Incidence of IHD The 5% relevant risk increase occurs at a noise exposure level of 59.3 dB L_{den}. The weighted average of the lowest noise levels measured in the studies was 53 dB L_{den} and the RR increase per 10 dB is 1.08.	5% increase of RR	High quality
Incidence of hypertension One study met the inclusion criteria. There was no significant increase of risk associated with increased noise exposure in this study.	10% increase of RR	Low quality
Prevalence of highly annoyed population There was an absolute risk of 10% at a noise exposure level of 53.3 dB $L_{den.}$	10% absolute risk	Moderate quality
Permanent hearing impairment	No increase	No studies met the inclusion criteria
Reading skills and oral comprehension in children	One-month delay	Very low quality

In accordance with the prioritization process (see section 2.4.3), the GDG set a guideline exposure level of 53.3 dB L_{den} for average exposure, based on the relevant increase of the absolute %HA. It was confident that there was an increased risk for annoyance below this noise exposure level, but probably no increased risk for other priority health outcomes. In accordance with the defined rounding procedure, the value was rounded to 53 dB L_{den}. As the evidence on the adverse effects of road traffic noise was rated moderate quality, the GDG made the recommendation strong.

Next, the GDG assessed the evidence for night noise exposure and its effect on sleep disturbance (Table 7).

Table 7. Night-time exposure levels (L_{night}) for priority health outcomes from road traffic noise

Summary of priority health outcome evidence	Benchmark level	Evidence quality
Sleep disturbance 3% of the participants in studies were highly sleep-disturbed at a noise level of **45.4 dB** L_{night}	3% absolute risk	Moderate quality

Based on the evidence of the adverse effects of road traffic noise on sleep disturbance, the GDG defined a guideline exposure level of 45.4 dB L_{night}. The exact exposure value was rounded to 45 dB L_{night}. As the evidence was rated moderate quality, the GDG made the recommendation strong.

The GDG also considered the evidence for the effectiveness of interventions. The results showed that:

- addressing the source by improving the choice of appropriate tyres, road surface, truck restrictions or by lowering traffic flow can reduce noise exposure;
- path interventions such as insulation and barrier construction reduce noise exposure, annoyance and sleep disturbance;
- changes in infrastructure such as construction of road tunnels lower noise exposure, annoyance and sleep disturbance;
- other physical interventions such as the availability of a quiet side of the residence reduce noise exposure, annoyance and sleep disturbance.

Given that it is possible to reduce noise exposure and that best practices already exist for the management of noise from road traffic, the GDG made a strong recommendation.

3.1.1.1 Other factors influencing the strength of recommendations

Other factors considered in the context of recommendations on road traffic noise included those related to values and preferences, benefits and harms, resource implications, equity, acceptability and feasibility; moreover, nonpriority health outcomes (the incidence of stroke and diabetes) were considered. Ultimately, the assessment of all these factors did not lead to a change in the strength of the recommendations. Further details are provided in section 3.1.2.3.

3.1.2 Detailed overview of the evidence

The following sections provide a detailed overview of the evidence constituting the basis for setting the recommendations on road traffic noise. It is presented and summarized separately for each of the critical health outcomes, and the GDG's judgement of the quality of evidence is indicated (for a detailed overview of the evidence on important health outcomes, see Annex 4). Research into health outcomes and effectiveness of interventions is addressed consecutively.

A comprehensive summary of all evidence considered for each of the critical and important health outcomes can be found in the eight systematic reviews published in the *International Journal of Environmental Research and Public Health* (see section 2.3.2 and Annex 2).

3.1.2.1 Evidence on health outcomes

The key question posed was: in the general population exposed to road traffic noise, what is the exposure–response relationship between exposure to road traffic noise (reported as various noise indicators) and the proportion of people with a validated measure of health outcome, when adjusted for main confounders? A summary of the PICOS/PECCOS scheme applied (see section 2.3.1) and the main findings is set out in Tables 8 and 9.

Table 8. PICOS/PECCOS scheme of critical health outcomes for exposure to road traffic noise

PECO	Description	
Population	General population	
Exposure	Exposure to high levels of noise produced by road traffic (average/night time)	
Comparison	Exposure to lower levels of noise produced by road traffic (average/night time)	
Outcome(s)	For average noise exposure: 1. cardiovascular disease 2. annoyance 3. cognitive impairment 4. hearing impairment and tinnitus 5. adverse birth outcomes 6. quality of life, well-being and mental health 7. metabolic outcomes	For night noise exposure: 1. effects on sleep

Table 9. Summary of findings for health effects from exposure to road traffic noise (L_{den})

Noise metric	Priority health outcome measure	Quantitative risk for adverse health	Lowest level of exposure across studies	Number of participants (studies)	Quality of evidence
Cardiovascular disease					
L_{den}	Incidence of IHD	RR = 1.08 (95% confidence interval (CI): 1.01–1.15) per 10 dB increase	53 dB	67 224 (7)	High (upgraded for dose-response)
L_{den}	Incidence of hypertension	RR = 0.97 (95% CI: 0.90–1.05) per 10 dB increase	N/A	32 635 (1)	Low (downgraded for risk of bias and because only one study was available)
Annoyance					
L_{den}	%HA	Odds ratio (OR) = 3.03 (95% CI: 2.59–3.55) per 10 dB increase	40 dB	34 112 (25)	Moderate (downgraded for inconsistency)
Cognitive impairment					
L_{den}	Reading and oral comprehension	Not estimated	N/A	Over 2844 (1)	Very low (downgraded for inconsistency)
Hearing impairment and tinnitus					
L_{den}	Permanent hearing impairment	–	–	–	–

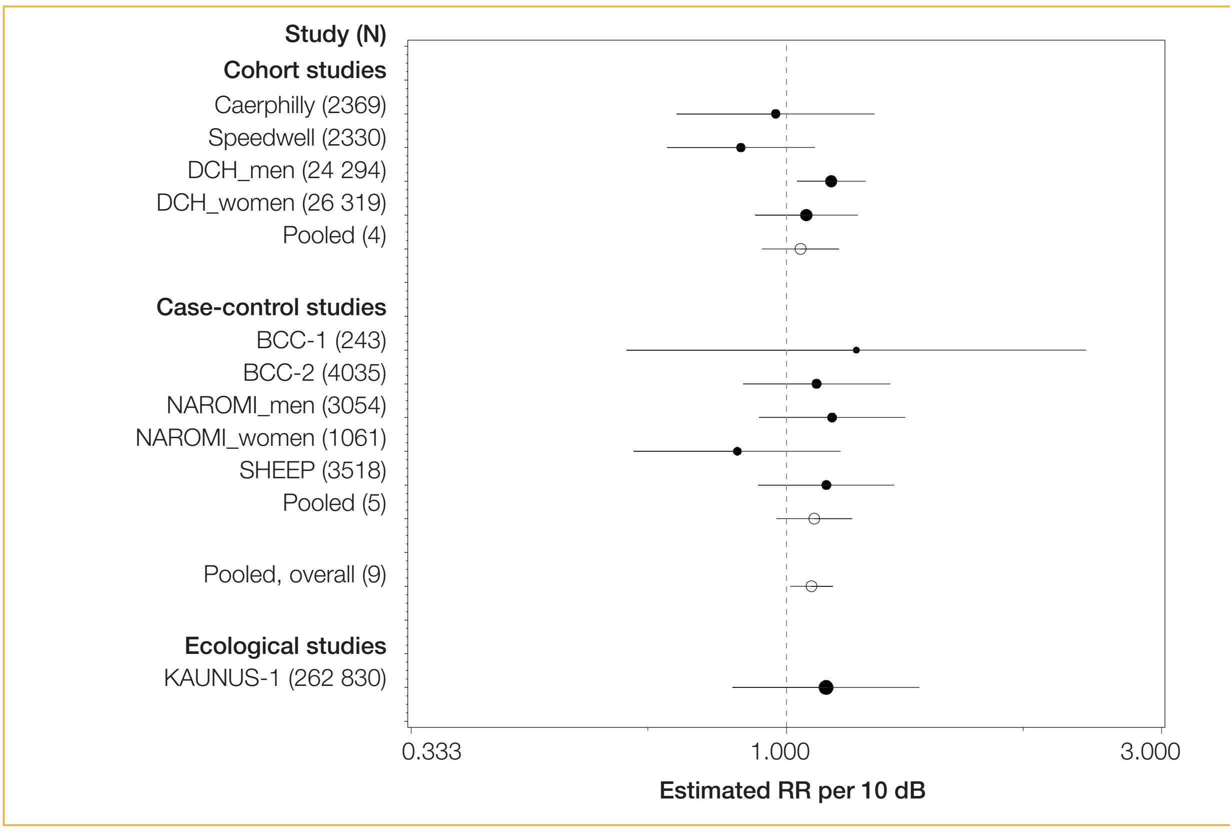
Cardiovascular disease

IHD

A total of three cohort (Babisch & Gallacher, 1990; Babisch et al., 1988; 1993a; 1993b; 1999; 2003; Caerphilly and Speedwell Collaborative Group, 1984; Sörensen et al., 2012a; 2012c) and four case-control studies (Babisch, 2004; Babisch et al., 1992; 1994; 2005a; Selander et al., 2009; Wiens, 1995) investigated the relationship between road traffic noise and the incidence of IHD. These involved a total of 67 224 participants, including 7033 cases. As identified in Fig. 1, the overall RR derived from the meta-analysis was 1.08 (95% CI: 1.01–1.15) per 10 dB L_{den} increase in noise levels, across a noise range of 40 dB to 80 dB. This evidence was rated high quality.

The data were supported by one ecological study conducted with 262 830 participants, including 418 cases, which also reported a statistically significant estimate (Grazuleviciene et al., 2004; Lekaviciute, 2007). In this study, a positive but nonsignificant association was found: RR of 1.12 (95% CI: 0.85–1.48) per 10 dB L_{den} increase in noise. This evidence was rated very low quality.

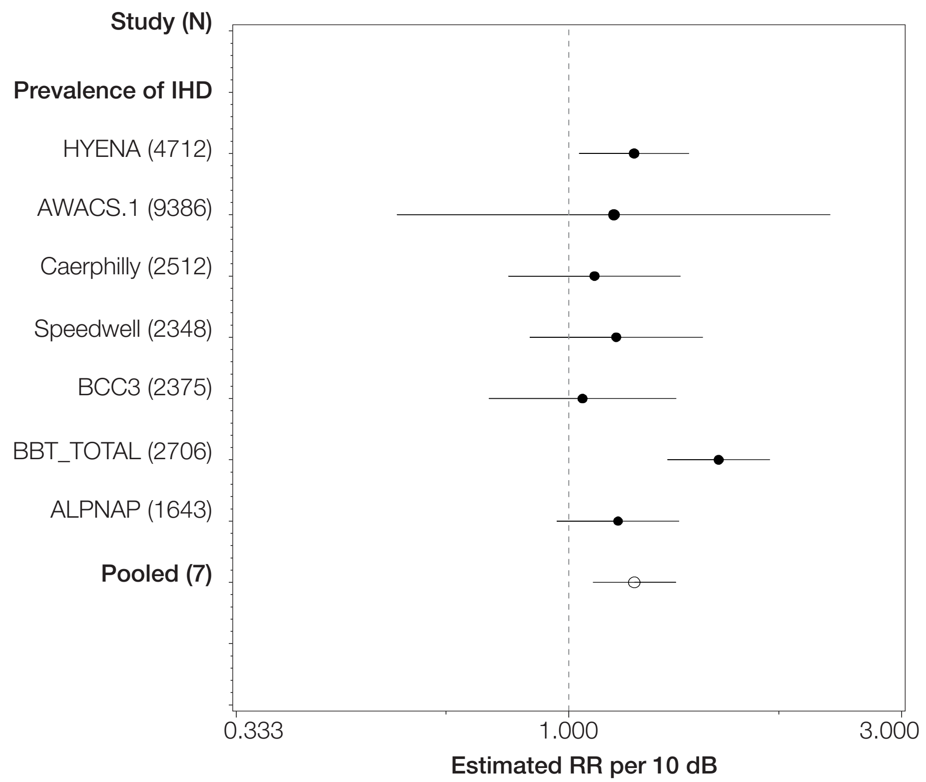
Fig. 1. The association between exposure to road traffic noise (L_{den}) and incidence of IHD



Notes: The dotted vertical line corresponds to no effect of exposure to road traffic noise. The black circles correspond to the estimated RR per 10 dB and 95% CI. The white circles represent the pooled random effect estimates and 95% CI. For further details on the studies included in the figure please refer to the systematic review on environmental noise and cardiovascular and metabolic effects (van Kempen et al., 2018).

Furthermore, additional evidence was available from eight cross-sectional studies that investigated the relationship between road traffic noise and prevalence of IHD (Babisch & Gallacher, 1990; Babisch et al., 1988; 1992; 1993a; 1993b; 1994; 1999; 2003; 2005a; 2008; 2012a; 2012b; Caerphilly and Speedwell Collaborative Group, 1984; Floud et al., 2011; 2013a; 2013b; Heimann et al., 2007; Jarup et al., 2005; 2008; Lercher et al., 2008; 2011; van Poll et al., 2014; Wiens, 1995). These studies involved a total of 25 682 participants, including 1614 cases. The overall RR was 1.24 (95% CI: 1.08–1.42) per 10 dB L_{den} increase in road traffic noise levels. The range in noise levels in the studies under evaluation was 30–80 dB. The results of the meta-analysis are presented in Fig. 2. This evidence was rated low quality.

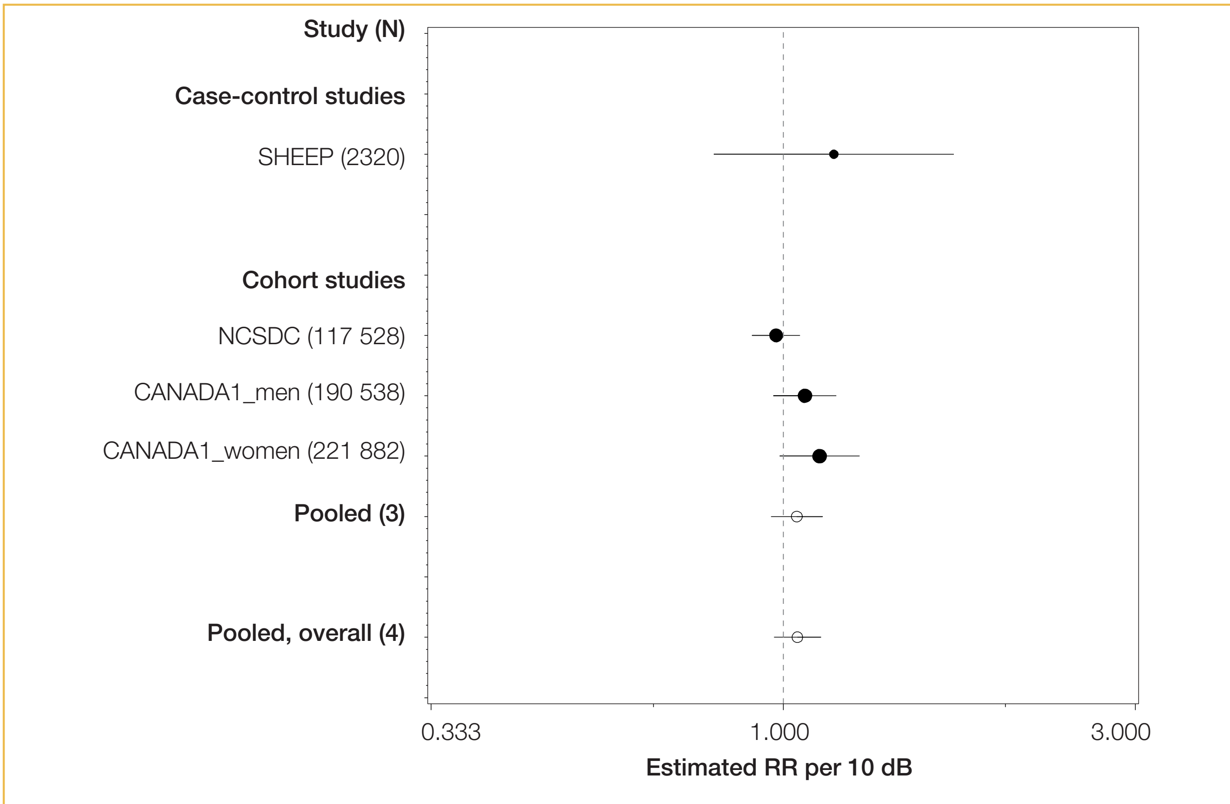
Fig. 2. The association between exposure to road traffic noise (L_{den}) and prevalence of IHD



Notes: The dotted vertical line corresponds to no effect of exposure to road traffic noise. The black circles correspond to the estimated RR per 10 dB and 95% CI. The white circle represents the pooled random effect estimates and 95% CI. For further details on the studies included in the figure please refer to the systematic review on environmental noise and cardiovascular and metabolic effects (van Kempen et al., 2018).

Mortality from IHD was also investigated in one case-control (Selander et al., 2009) and two cohort studies (Beelen et al., 2009; Gan et al., 2012), which involved 532 268 participants, including 6884 cases. The quantitative relationship between road traffic noise and mortality from IHD was RR = 1.05 (95% CI: 0.97–1.13) per 10 dB L_{den} increase in noise levels (see Fig. 3). This evidence was rated moderate quality.

Fig. 3. The association between exposure to road traffic noise (L_{den}) and mortality from IHD



Notes: The dotted vertical line corresponds to no effect of exposure to road traffic noise. The black circles correspond to the estimated RR per 10 dB and 95% CI. The white circles represent the pooled random effect estimates and 95% CI. For further details on the studies included in the figure please refer to the systematic review on environmental noise and cardiovascular and metabolic effects (van Kempen et al., 2018).

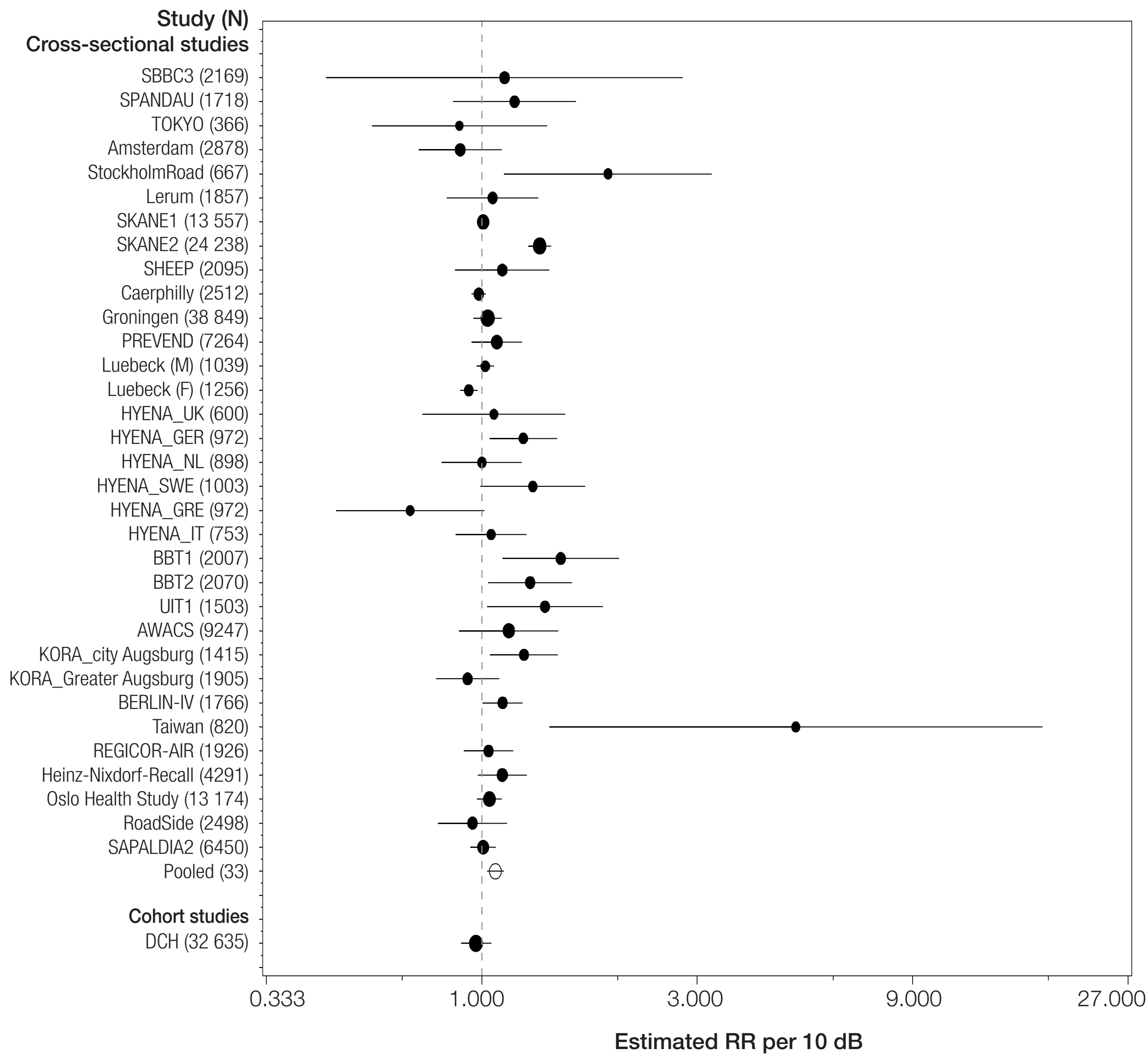
Hypertension

One cohort study into the relationship between road traffic noise and incidence of hypertension was identified; it involved 32 635 participants, including 3145 cases (Sörensen et al., 2011; 2012c). The study found a nonsignificant effect size of 0.97 (95% CI: 0.90–1.05) per 10 dB L_{den} increase in noise levels, which does not support an increased risk of hypertension due to exposure to road traffic noise. Because of the risk of bias and the availability of only one study, this evidence was rated low quality.

In addition, 26 cross-sectional studies were identified that looked at the association between road traffic noise and prevalence of hypertension (Babisch et al., 1988; 1992; 1994; 2005a; 2008; 2012a; 2012b; 2013a; 2013b; 2014b; 2014c; Barregard et al., 2009; Bjork et al., 2006; Bluhm et al., 2007; Bodin et al., 2009; Caerphilly and Speedwell Collaborative Group, 1984; Chang et al., 2011; 2014; de Kluizenaar et al., 2007a; 2007b; Dratva et al., 2012; Eriksson et al., 2012; Foraster et al., 2011; 2012; 2013; 2014a; 2014b; Fuks et al., 2011; Hense et al., 1989; Herbold et al., 1989; Jarup et al., 2005; 2008; Knipschild et al., 1984; Lercher et al., 2008; 2011; Maschke, 2003; Maschke & Hecht, 2005; Maschke et al., 2003; Oftedal et al., 2011; 2014; Selander et al., 2009; van Poll et al., 2014; Wiens, 1995; Yoshida et al., 1997). In total, these studies involved 154 398 participants, including 18 957 cases. The overall RR for prevalence of hypertension was 1.05 (95% CI: 1.02–1.08) per 10 dB L_{den} increase in noise levels. The noise range of the studies under evaluation was 20–85 dB. The overall evidence was rated very low quality.

Fig. 4 shows the association between road traffic noise and incidence and prevalence of hypertension.

Fig. 4. The association between exposure to road traffic noise (L_{den}) and hypertension



Notes: The dotted vertical line corresponds to no effect of exposure to road traffic noise. The black dots correspond to the estimated RR per 10 dB and 95% CI. The white circle represents the summary estimate and 95% CI. For further details on the studies included in the figure please refer to the systematic review on environmental noise and cardiovascular and metabolic effects (van Kempen et al., 2018).

Stroke

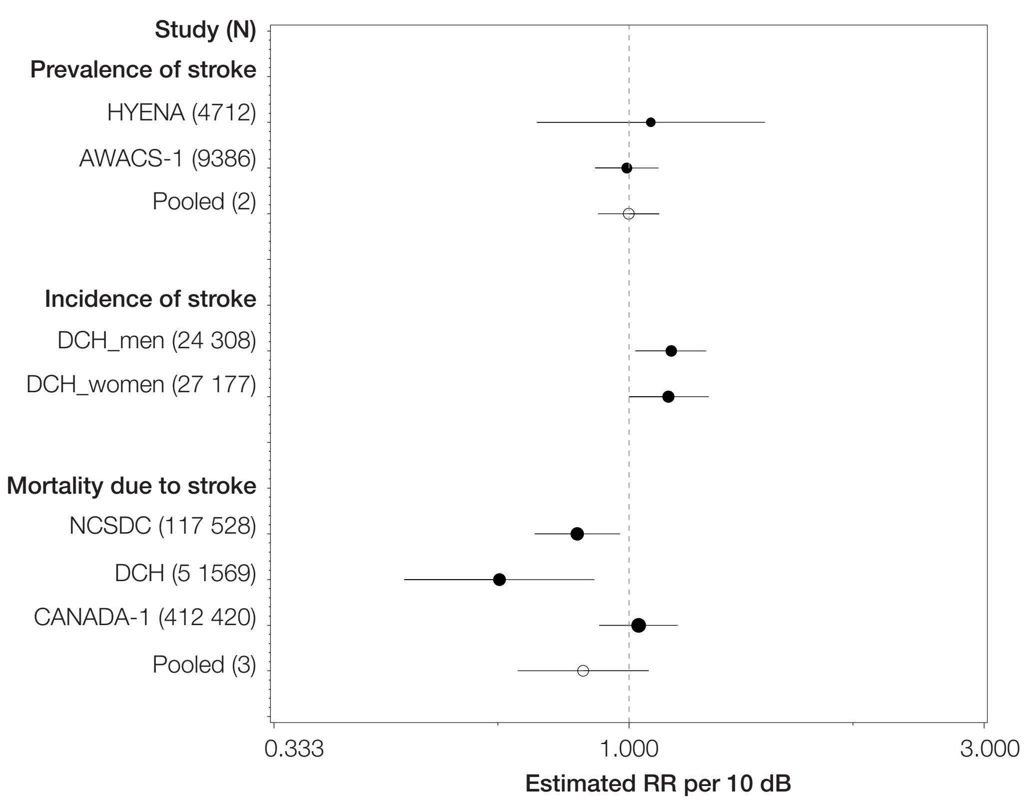
One cohort study into the relationship between road traffic noise and incidence of stroke was identified (Sörensen et al., 2011; 2012b; 2014). It involved 51 485 participants, including 1881 cases, and found an RR of 1.14 (95% CI: 1.03–1.25) per 10 dB L_{den} increase in noise levels, across a range of around 50–70 dB. The evidence was rated moderate quality.

Two cross-sectional studies on road traffic noise and prevalence of stroke involved 14 098 participants, including 151 cases (Babisch et al., 2005a; 2008; 2012a; 2012b; 2013a; Floud et al., 2011; 2013a; 2013b; Jarup et al., 2005; 2008; van Poll et al., 2014) yielded an estimated RR of 1.00 (95% CI: 0.91–1.10) per 10 dB L_{den} increase in noise levels. This evidence was rated very low quality.

Furthermore, three cohort studies investigated the relationship between road traffic noise and mortality due to stroke (Beelen et al., 2009; Gan et al., 2012; Sörensen et al., 2011; 2012b; 2014). These involved 581 517 participants, including 2634 cases, and their pooled estimate was a statistically nonsignificant RR = 0.87 (95% CI: 0.71–1.06) per 10 dB L_{den} increase in road traffic noise levels. This evidence was rated moderate quality.

Fig. 5 presents the results of the meta-analysis for road traffic noise and measures of stroke.

Fig. 5. The association between exposure to road traffic noise (L_{den}) and stroke



Notes: The dotted vertical line corresponds to no effect of exposure to road traffic noise. The black dots correspond to the estimated RR per 10 dB and 95% CI. The white circles represent the summary estimate and 95% CI.
For further details on the studies included in the figure please refer to the systematic review on environmental noise and cardiovascular and metabolic effects (van Kempen et al., 2018).

Children's blood pressure

Six cross-sectional studies investigated the change in systolic and diastolic blood pressure in children exposed to road traffic noise in residential settings (Belojevic & Evans, 2011; 2012; Bilenko et al., 2013; Liu et al., 2013; 2014; Regecova & Kellerova, 1995; van Kempen et al., 2006). In total, 4197 children were included in these studies; the number of cases was not reported. For each increase in 10 dB L_{den} in noise levels, there was a statistically nonsignificant increase in systolic and in diastolic blood pressure of 0.08 mmHg (95% CI: –0.48–0.64) and 0.47 mmHg (95% CI: –0.30–1.24), respectively. The overall evidence was rated very low quality.

Furthermore, five cross-sectional studies investigated the association between systolic and diastolic blood pressure in children and exposure to road traffic noise in educational settings (Belojevic & Evans, 2011; 2012; Bilenko et al., 2013; Clark et al., 2012; Paunovic et al., 2013; Regecova & Kellerova, 1995; van Kempen et al., 2006). In total, 4520 children were included in these studies; the number of cases was not reported. Systolic blood pressure decreased statistically nonsignificantly, at –0.60 mm (95% CI: –1.51–0.30) per 10 dB L_{den} increase in road traffic noise levels. Diastolic blood pressure increased statistically nonsignificantly, at 0.46 mm (95% CI: –0.60–1.53) per 10 dB L_{den} increase in road traffic noise levels. For both relationships, the evidence was rated very low quality.

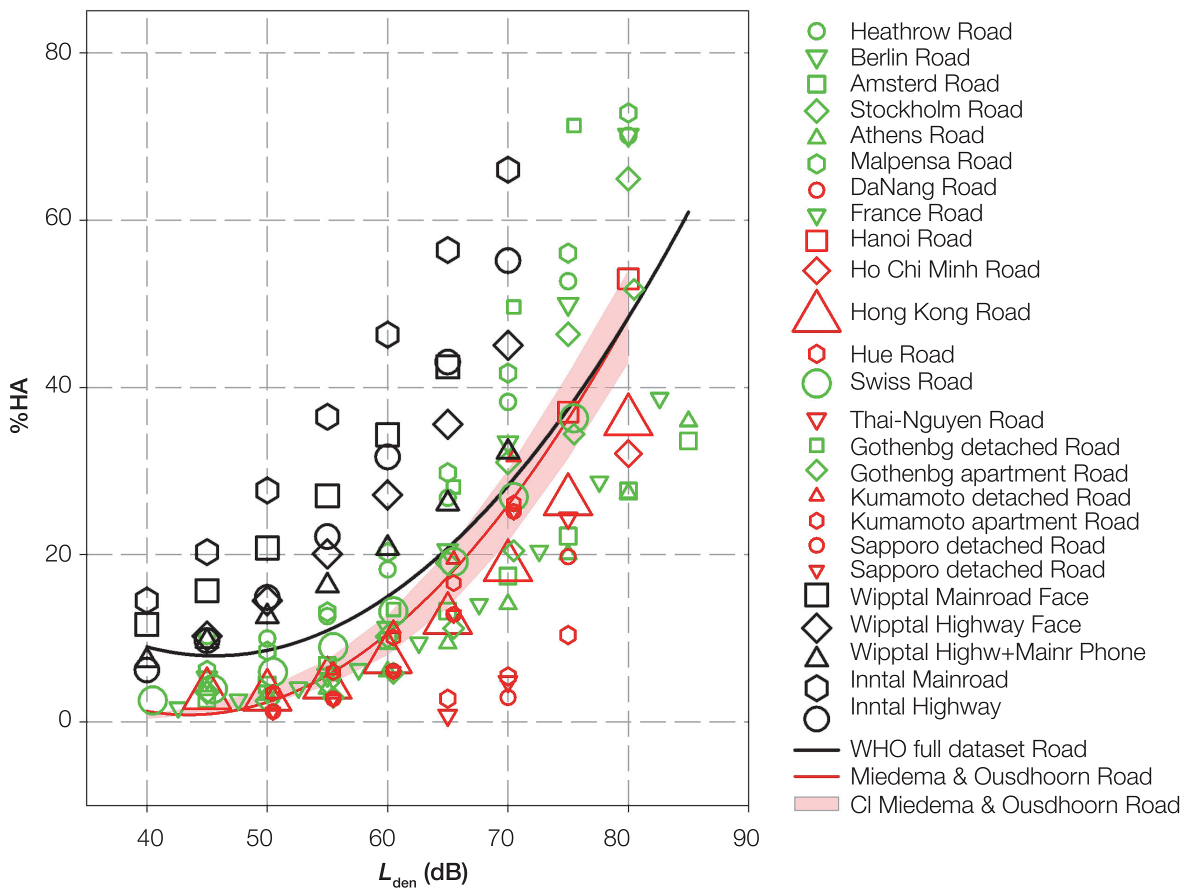
Annoyance

A vast amount of research proves the association between road traffic noise and annoyance. In total, 17 road traffic noise studies were identified that were used to model ERFs of the relationship between L_{den} and %HA (Babisch et al., 2009; Brink, 2013; Brink et al., 2016; Brown et al., 2014; 2015; Champelovier et al., 2003; Heimann et al., 2007; Lercher et al., 2007; Medizinische Universitaet Innsbruck, 2008; Nguyen et al., 2012a; Pierette et al., 2012; Sato et al., 2002; Shimoyama et al., 2014). These incorporated data from 34 112 study participants. The estimated data points of each of the studies are plotted in Fig. 6, alongside an aggregated ERF including the data from all the individual studies (see the black line for "WHO full dataset"). The lowest category of noise exposure considered in any of the studies, and hence included in the systematic review, is 40 dB, corresponding to approximately 9%HA. The benchmark level of 10%HA is reached at 53.3 dB L_{den} (see Fig 6).

Table 10 shows the %HA in relation to exposure to road traffic noise. The calculations are based on the regression equation $\%HA = 78.9270–3.1162 \times L_{den} + 0.0342 \times L_{den}^{2}$ derived from the systematic review (Guski et al., 2017). Even though there is a large evidence base substantiating the association of average road traffic noise and noise annoyance, the overall evidence had to be rated low quality. The main reasons for downgrading included limitations regarding the acoustical data provided, the nature of study design (most of the studies in the realm of annoyance research follow a cross-sectional approach), the inconsistency of results and the variety in the questions asked.

Nevertheless, the general quality of the evidence was substantiated with the help of additional statistical analyses that apply classic health outcome measures to estimate noise annoyance. When comparing road traffic noise exposure at 50 dB and 60 dB, the analyses revealed evidence rated moderate quality for an association between road traffic noise and %HA for an increase per 10 dB (OR = 2.74; 95% CI: 1.88–4.00). Moreover, there was evidence rated high quality for the increase of %HA per 10 dB increase in sound exposure, when data on all sound classes were included (OR = 3.03; 95% CI: 2.59–3.55).

Fig. 6.Scatterplot and quadratic regression of the relationship between road traffic noise (L_{den}) and annoyance (%HA)



Notes: The ERF by Miedema & Oudshoorn (2001) is added in red for comparison.
The size of the data points corresponds to the number of participants in the respective study (size = SQRT(N)/10).
If two results from different studies fall on the same data point, the last point plotted may mask the former one.
The black curve is derived from aggregated secondary data, while the red one is derived from individual data.
There is no indication of 95% CIs of the WHO full dataset, as a weighting based on the total number of participants for each 5 dB L_{den} sound class could not be calculated; weighting based on all participants of all sound classes proved to be unsuitable. The range of data included is illustrated by the distribution of data points.
For further details on the studies included in the figure please refer to the systematic review on environmental noise and annoyance (Guski et al., 2017).

Table 10. The association between exposure to road traffic noise (L_{den}) and annoyance (%HA)

L_{den} (dB)	%HA
40	9.0
45	8.0
50	8.6
55	11.0
60	15.1
65	20.9
70	28.4
75	37.6
80	48.5

Cognitive impairment

Evidence rated very low quality was available for the association between road traffic noise and reading and oral comprehension, assessed by tests. The review identified two papers that reported the results of the cross-sectional road traffic and aircraft noise exposure and children's cognition and health (RANCH) study, which examined exposure–effect relationships (Clark et al., 2006; Stansfeld et al., 2005). The study of over 2000 children aged 9–10 years, attending 89 schools around three major airports in the Netherlands, Spain and the United Kingdom did not find an exposure–effect relationship between road traffic noise exposure at primary school, which ranged from 31 to 71 dB $L_{Aeq,16h}$, and children's reading comprehension.

Few studies have investigated other health outcome measures related to cognition. Evidence rated low quality was available for an association between road traffic noise and cognitive impairment assessed through standardized tests (Cohen et al., 1973; Lukas et al., 1981; Pujol et al., 2014; Shield & Dockrell, 2008). There was evidence rated very low quality for an association between road traffic noise and long-term memory (Matheson et al., 2010; Stansfeld et al., 2005). No studies examined effects on short-term memory.

There was evidence rated very low quality, however, that road traffic noise does not have a considerable effect on children's attention (Cohen et al., 1973; Stansfeld et al., 2005). Further, there was evidence rated low quality that road traffic noise does not have a substantial effect on executive function (working memory), with studies consistently reporting no association (Clark et al., 2012; Matheson et al., 2010; Stansfeld et al., 2005; van Kempen et al., 2010; 2012).

Hearing impairment and tinnitus

No studies were found, and therefore no evidence was available for the association between road traffic noise and hearing impairment and tinnitus.

Sleep disturbance

For road traffic noise and self-reported sleep outcomes (awakenings from sleep, the process of falling asleep and sleep disturbance), 12 studies were identified that included a total of 20 120 participants (Bodin et al., 2015; Brown et al., 2015; Hong et al., 2010; Phan et al., 2010; Ristovska et al., 2009; Sato et al., 2002; Shimoyama et al., 2014); these were cross-sectional studies, conducted in healthy adults. The health outcome was measured by self-reporting via general health and noise surveys that included questions about sleep in general, and other questions about how noise affects sleep (see Table 11).

Table 11. Summary of findings for health effects from exposure to road traffic noise (L_{night})

Noise metric	Priority health outcome measure	Quantitative risk for adverse health	Lowest level of exposure across studies	Number of participants (studies)	Quality of evidence
Effects on sleep					
L_{night}	%HSD	OR: 2.13 (95% CI: 1.82–2.48) per 10 dB increase	43 dB	20 120 (12)	Moderate (downgraded for study limitations, inconsistency; upgraded for dose-response, magnitude of effect)

The model in the systematic review (Basner & McGuire, 2018) was based on outdoor L_{night} levels between 40 dB and 65 dB only; 40 dB was chosen as the lower limit because of possible inaccuracies of predicting lower noise levels. The range of noise exposure reported in the studies reviewed was 37.5–77.5 dB L_{night}. About 2% (95% CI: 0.90–3.15) of the population was characterized as highly sleep-disturbed at L_{night} levels of 40 dB. The %HSD at other, higher levels of road traffic noise is presented in Table 12. The association between road traffic noise and the probability of being highly sleep-disturbed was OR: 2.13 (95% CI: 1.82–2.48) per 10 dB increase in noise. This evidence was rated moderate quality.

Table 12. The association between exposure to road traffic noise (L_{night}) and sleep disturbance (%HSD)

L_{night} (dB)	%HSD	95% CI
40	2.0	0.9–3.15
45	2.9	1.40–4.44
50	4.2	2.14–6.27
55	6.0	3.19–8.84
60	8.5	4.64–12.43
65	12.0	6.59–17.36

Additional analyses were conducted for other health outcome measures related to sleep, which provided supporting evidence on the overall relationship between road traffic noise and sleep disturbance. When the noise source was not specified in the question, the relationship between road traffic noise and self-reported sleep outcomes was still positive but no longer statistically significant, with an OR of 1.09 (95% CI: 0.94–1.27) per 10 dB increase (Bodin et al., 2015; Brink, 2011; Frei et al., 2014; Halonen et al., 2012). This evidence was rated very low quality.

There was evidence rated moderate quality for an association between road traffic noise and sleep outcomes measured with polysomnography (probability of additional awakenings) with an OR of 1.36 (95% CI: 1.19–1.55) per 10 dB increase in indoor $L_{AS,max}$ [13] (Basner et al., 2006; Elmenhorst et al., 2012). Further, evidence rated low quality showed an association between road traffic noise and sleep outcomes measured as motility in adults (Frei et al., 2014; Griefahn et al., 2000; Oehrstroem et al., 2006a; Passchier-Vermeer et al., 2007; Pirrera et al., 2014). Finally, there was evidence rated very low quality for an association between road traffic noise and both self-reported and motility-measured sleep disturbance in children (Ising & Ising, 2002; Lercher et al., 2013; Oehrstroem et al., 2006a; Tiesler et al., 2013).

3.1.2.2 Evidence on interventions

This section summarizes the evidence underlying the recommendation on the effectiveness of interventions for road traffic noise exposure. The key question posed was: in the general population exposed to road traffic noise, are interventions effective in reducing exposure to and/or health outcomes from road traffic noise? A summary of the PICOS/PECCOS scheme applied and the main findings is set out in Tables 13 and 14.

Table 13. PICOS/PECCOS scheme of the effectiveness of interventions for exposure to road traffic noise

PICO	Description	
Population	**General population**	
Intervention(s)	The interventions can be defined as: (a) a measures that aim to change noise exposure and associated health effects; (b) a measures that aim to change noise exposure, with no particular evaluation of the impact on health; or (c) a measures designed to reduce health effects, but that may not include a reduction in noise exposure.	
Comparison	**No intervention**	
Outcome(s)	For average noise exposure: 1. cardiovascular disease 2. annoyance 3. cognitive impairment 4. hearing impairment and tinnitus 5. adverse birth outcomes 6. quality of life, well-being and mental health 7. metabolic outcomes	For night noise exposure: 1. effects on sleep

[13] $L_{AS,max}$ is the maximum time-weighted and A-weighted sound pressure level with SLOW time constant within a stated time interval starting at t1 and ending at t2, expressed in dB.

Table 14. Summary of findings for road traffic noise interventions by health outcome

Type of intervention	Number of participants (studies)	Effect of intervention	Quality of evidence
Annoyance			
Type A – source interventions (change in traffic flow rate, improved road resurfacing, truck restriction strategy, complex set of barriers, road surfaces and other measures)	6096[a] (9)	• Changes in noise level ranged from around −15 dB to +15.5 dB (various noise metrics). • Most studies found that the intervention resulted in a change in annoyance.	Moderate (downgraded for study limitations; upgraded for dose-response)
Type B – path interventions (dwelling insulation, barrier construction, building intervention)	2970 (7)	• Changes in noise level ranged from −3 dB to −13 dB (various noise metrics). • All studies found that the intervention resulted in a change in annoyance, as estimated by an ERF.	Moderate (downgraded for study limitations; upgraded for dose-response)
Type C – changes in infrastructure (new road tunnel infrastructure)	1211 (2)	• Noise levels reduced by an average of −12 dB ($L_{Aeq,24h}$). • Both studies found lower annoyance responses post intervention, with no change in the controls.	Moderate (downgraded for study limitations; upgraded for dose-response)
Type D – other physical interventions (availability of quiet side to the dwelling, existence of nearby green space)	26 786 (6)	• Because of large variability in noise levels between most and least exposed façade (quiet side), access to quiet side and/or green space resulted in less annoyance.	Very low (downgraded for study limitations)
Sleep disturbance			
Type B – path interventions (1: façade insulation; 2: enlargement of motorway lanes but with dwelling insulation, barriers and quiet pavement)	1158 (2)	• 1: façade insulation resulted in a reduction of 7 dB for indoor noise level. • 2: enlargement led to reduction in the extent of population exposure at higher noise levels (55–65 dB) with an increase in lower levels (45–55 dB) • Both path interventions resulted in changes in sleep outcomes	Moderate (downgraded for study limitations)
Type C – changes in infrastructure (new road tunnel infrastructure)	166 (2)	• Noise levels reduced by an average of −12 dB ($L_{Aeq,24h}$). • Both studies found lower sleep disturbance indicators/ improvement in sleep post intervention, with no change in the controls.	Moderate (downgraded for study limitations)
Type D – other physical interventions (availability of quiet side to the dwelling)	100 (1)	• An absence of quiet façade resulted in increased reporting of difficulty in falling asleep.	Very low (downgraded for study limitations, inconsistency)
Cardiovascular disease			
Type D – other physical interventions (availability of quiet side to the dwelling)	9203 (4)	• Three studies found changes (including in self-reported hypertension) with and without a quiet side. One study found no change.	Very low (downgraded for study limitations)

Note: [a] This figure does not include number of participants from the studies by Langdon & Griffiths (1982) and Baughan & Huddart (1993), as the exact number of respondents was not reported.

Type A – source interventions

Most of the nine source intervention studies – Baughan & Huddart (1993), Brown (1987; 2015), Brown et al. (1985), Griffiths & Raw (1987; 1989), Kastka (1981), Langdon & Griffiths (1982), Pedersen et al. (2013; 2014), Stansfeld et al. (2009b) – showed an effect in annoyance due to changes in road traffic flow rates. In some cases these were combined with other measures like improved road resurfacing, truck restrictions or complex control measures, including barriers or road surfaces. A majority of the changes resulted in reductions of noise levels.

Regarding the strength of association between exposure and annoyance outcome, all intervention studies demonstrated that the response was of at least the magnitude estimated by a steady-state ERF. The limited available evidence on long-term effects shows that this excess response undergoes some attenuation but is largely maintained over several years. In spite of the high risk of bias in all studies, the evidence in the systematic review was initially assessed as high quality, due to an upgrade because of the dose-response effect. However, the GDG decided to downgrade this assessment in an effort to maximize consistency with the grading approach of the remaining systematic reviews. It was therefore rated moderate quality.

Type B – path interventions

Seven path intervention studies – Amundsen et al. (2011; 2013), Bendtsen et al. (2011), Gidloef-Gunnarsson et al. (2010), Kastka et al. (1995), Nilsson & Berglund (2006), Vincent & Champelovier (1993) – explored the effects on annoyance by interventions related to dwelling insulation, barrier constructions and a combination of both, as well as a full-scale building intervention. With the help of pre/post designs, the studies assessed changes in noise exposure achieved by the interventions over different periods of time. In six studies the path intervention was associated with a change in annoyance outcomes. Four of these showed that the annoyance response to the change was in the same direction and of at least the same magnitude estimated by the ERF. In spite of the high risk of bias in all studies, the evidence in the systematic review was initially assessed as high quality, due to an upgrade because of the dose-response effect. However, the GDG decided to downgrade this assessment in an effort to maximize consistency with the grading approach of the remaining systematic reviews. The evidence was therefore rated moderate quality.

Two of the studies (Amundsen et al., 2013; Bendtsen et al., 2011) assessed path interventions and sleep disturbance. The results showed a reduction in the %HSD after the interventions were conducted. One of the studies included a two-year follow-up, revealing the persistence of the effect. Risk of bias was assessed as high in both studies. The evidence was rated moderate quality.

Type C – new/closed infrastructure interventions

Two infrastructural intervention studies (Gidloef-Gunnarsson et al., 2013; Oehrstroem, 2004; Oehrstroem & Skanberg, 2000) evaluated the impact on annoyance of major reductions in road traffic flows, combined with other environmental improvements. One was a new road tunnel infrastructure, resulting in substantial traffic and noise levels reductions for residents near the previously heavy-traffic road. Both studies were pre/post designs using repeated measures of annoyance outcomes. Following the reduction in noise levels (around –12 dB $L_{Aeq,24h}$), both studies demonstrated a statistically significant lower degree of annoyance, while there was no change in the control group. Both also reported that the after-scores in the studies matched those estimated by the ERF, but both reported excess response, meaning that the response to change was in the direction estimated by the ERF but much steeper. In spite of the high risk of bias in all studies, the quality of the evidence in the systematic review was initially assessed as high, due to an upgrade because of the dose-response effect. However, the GDG decided to downgrade this assessment in an effort to maximize consistency with the grading approach of the remaining systematic reviews. The evidence was therefore rated moderate quality.

Two studies investigated the impact of new tunnels that removed traffic flow from surface roads on sleep disturbance (Oehrstroem, 2004; Oehrstroem & Skanberg, 2000; 2004). Subjective and objective measures of sleep quality were assessed before and after the intervention. Both studies demonstrated a statistically significant lower reporting of various sleep disturbance indicators post intervention. One study reported statistically significantly reduced time spent in bed after the intervention, which, according to the authors, could suggest increased sleep efficiency. Risk of bias was assessed as high, so this evidence was rated moderate quality.

Type D – other physical infrastructure interventions

No intervention studies were available to assess impacts on annoyance of other physical interventions. The only relevant studies (Babisch et al., 2012; de Kluizenaar et al, 2011; 2013; Gidloef-Gunnarsson & Oehrstroem 2007; van Renterghem & Botteldooren, 2012; 2010) did not provide direct evidence of an intervention. Instead, they provided indirect evidence on the magnitude of the likely effect of certain interventions (e.g. using the quiet side of the dwelling, green space in the neighbourhood) by comparing responses from groups with and without the intervention/feature of interest. All studies found an effect of the presence of the dimension investigated; in all but one, the effect was statistically significant. Risk of bias was assessed as high in all studies, so the evidence was rated very low quality.

One study investigated a subjective assessment of difficulty in falling asleep (van Renterghem & Botteldooren, 2012), before and after the intervention. The difference in the proportion of participants reporting difficulty falling asleep "at least sometimes" between homes with and without a quiet side was statistically significant. Absence of a quiet façade resulted in increased reporting of this sleep parameter. Confounding was adjusted for in the analyses of the ERFs, including noise sensitivity, window-closing behaviour and front-façade L_{den}. Risk of bias was assessed as high, so the evidence was rated very low quality.

Four studies that assessed the effect of other physical interventions on cardiovascular disease were identified (Babisch et al., 2012; 2014a; Bluhm et al., 2007; Lercher et al., 2011). Three of these found changes, including self-reported hypertension, with and without a quiet side of the dwelling; in two the difference was statistically significant. The risk of bias in these studies was generally high, so the evidence was rated very low quality.

3.1.2.3 Consideration of additional contextual factors

As the foregoing overview has shown, ample evidence about the adverse health effects of long-term exposure to road traffic noise exists. Based on the quality of the available evidence, the GDG set the strength of the recommendation on road traffic noise at strong. As a second step, it qualitatively assessed contextual factors to explore whether other considerations could have a relevant impact on the recommendation strength. These considerations mainly concerned the balance of harms and benefits, values and preferences, equity, and resource use and implementation.

When assessing the balance of harms and benefits of interventions to reduce exposure to road traffic noise, the GDG initially noted that road traffic is the most widespread source of noise pollution, measured in terms of the number of affected people both within and outside urban areas. The EEA estimates that more than 100 million people in Europe are exposed to L_{den} levels above 55 dB; for night-time road traffic noise, over 72 million Europeans are exposed to L_{night} levels above 50 dB (Blanes et al., 2017).[14] The amount of road traffic noise emitted is unlikely to decrease significantly: both transport demand, including for passenger cars (EC, 2016b), and the number of city inhabitants (Eurostat, 2016) are expected to increase. Considering the significant burden of disease attributable to exposure to road traffic noise (WHO Regional Office for Europe & JRC, 2011), the GDG expects substantial health benefits to evolve from implementing the recommendations to reduce population exposure to road traffic noise. Depending on the intervention measures used (such as restrictions of traffic), possible harms could include effects on the transportation of goods and on individual mobility of the population. Both can have impacts on local, national and international economies. Overall, the GDG estimated that the benefits gained from minimizing adverse health effects due to road traffic noise exposure outweigh the possible (economic) harms.

Considering values and preferences, it has been established that people appreciate quiet areas as beneficial for their health and well-being, especially in urban areas (Shepherd et al., 2013; Gidloef-Gunnarsson & Oehrstroem, 2007; Oehrstroem et al., 2006b). Nevertheless, the GDG recognized that the convenience of individual mobility with the help of passenger cars is valued overall by large parts of the population in the EU, as illustrated by the sustained high volume of passenger kilometres driven in Europe (EEA, 2016a; 2017a). In general, values and preferences are expected to vary throughout society, as exposure to environmental noise and continuous road traffic noise is not equally distributed: those of individuals directly affected by long-term road traffic exposure are likely to differ from those that are not affected. Individuals with a higher average sound pressure level of road traffic noise are, for example, more willing to pay to reduce their noise exposure (Bristow et al., 2014).

In light of the dimension of equity, the GDG highlighted the fact that the risk of exposure to road traffic noise is not equally distributed throughout society. People with lower socioeconomic status and other disadvantaged groups often live in more polluted and louder areas, including in proximity to busy roads (EC, 2016a). Moreover, socioeconomic factors are not only related to differences in exposure to environmental factors such as noise but are also associated with increased vulnerability and poorer coping capacities (Karpati et al., 2002).

With resource use and implementation considerations, the GDG recognized that no comprehensive cost–benefit analysis for the WHO European Region yet exists, so this assessment is based on informed expert judgement regarding the feasibility of implementing the recommendation for the majority of the population. As the systematic review of environmental noise interventions and their

[14] These are gap-filled figures based on the reported data and including the situation both within and outside cities, as defined by the END.

associated impact on health shows, various effective measures exist to reduce noise exposure from road traffic and improve health (Brown & van Kamp, 2017). The resources needed to implement these measures vary as they rely on the type of intervention and the context. The GDG pointed out the following four major solutions, which are known to be cost-effective: choice of appropriate tyres, use of low-noise road surfaces, building of noise barriers and installation of soundproof windows (CSES et al., 2016). Other types of intervention include limitations of speed or type of traffic allowed on roads.

Regarding feasibility of implementation, the GDG was convinced that many of the solutions can be planned as part of regular maintenance processes and accelerated fleet and road modernization. In particular, appropriate tyres and road surfaces are only slightly more expensive than existing products, and various countries have already considered or adopted similar interventions to reduce noise levels (Ohiduzzaman et al., 2016; Sirin, 2016). This indicates that solutions to achieve recommended noise levels can be implemented and carry a reasonable cost on a societal level. The GDG noted, however, that the feasibility of implementing measures can be hindered by the fact that costs and benefits are not evenly distributed. In most cases, the health benefits gained by interventions that reduce long-term road traffic exposure accrue to citizens, whereas the costs are borne by road users, private companies and public authorities. Furthermore, the GDG expects challenges in the implementation of all long-term measures that include changes in behaviour of the population, such as increased use of car-sharing or public transport. Even though the overall costs are expected to be significant, because of the large number of people affected, the benefit of implementation of the recommendation to minimize the risk of adverse health effects due to road traffic noise for a majority of the population exceeds the resources needed.

In light of the assessment of the contextual factors in addition to the quality of evidence, the recommendation remains strong.

Other nonpriority adverse health outcomes

As an additional consideration, although not priority health outcomes and coming from a single study, the GDG noted the evidence rated moderate quality for an association between road traffic noise and the prevalence of diabetes (van Kempen et al., 2018). The noise levels in the study identified ranged from around 50 dB to 70 dB L_{den}, so the recommendation proposed is thought to be protective enough for this health outcome. Thus, it did not lead to a change in the recommendation.

Additional considerations or uncertainties

Individual noise annoyance judgements of residents are to a large extent moderated by personal variables (such as noise sensitivity and coping capacity). However, further situational factors that apply to many residents should be taken into account when analysing noise annoyance from road traffic noise, as they may moderate the relationship. These include the type(s) of road being considered (highways, urban main roads, secondary roads and so on) and the related traffic composition (share of cars, motorcycles and heavy and loud trucks) and pattern (fluctuation, frequency, intermittency). Moreover, the location of settlements and/or individual dwellings, proximity to the road, and location and availability of a quiet façade can also influence the relationship when predicting health outcomes such as annoyance.

3.1.3 Summary of the assessment of the strength of the recommendations

Table 15 provides a comprehensive summary of the different dimensions for the assessment of the strength of the road traffic noise recommendations.

Table 15. Summary of the assessment of the strength of the road traffic noise recommendation

Factors influencing the strength of recommendation	Decision
Quality of evidence	**Average exposure** (L_{den}) *Health effects* • Evidence for a relevant RR increase for incidence of IHD at **59 dB** L_{den} was rated **high quality**. • Evidence for the incidence of hypertension was rated **low quality**. • Evidence for a relevant absolute risk of annoyance at **53 dB** L_{den} was rated **moderate quality**. • Evidence for a relevant RR increase for reading and oral comprehension was rated **very low quality**. *Interventions* • Evidence on effectiveness of interventions to reduce noise exposure and/or health outcomes from road traffic noise is of varying quality. **Night-time exposure** (L_{night}) *Health effects* • Evidence for a relevant absolute risk of sleep disturbance related to night noise exposure from road traffic at **45 dB** L_{night} was rated **moderate quality**. *Interventions* • Evidence on effectiveness of interventions to reduce noise exposure and/or sleep disturbance from road traffic noise is of varying quality.
Balance of benefits versus harms and burdens	Health benefits can be gained from markedly reducing exposure of the population to road traffic noise; benefits outweigh the harms of interventions to reduce continuous road traffic noise.
Values and preferences	Quiet areas are valued by the population, especially by those affected by continuous noise exposure. Some variability is possible between those who benefit from interventions to reduce road traffic noise and those who finance the interventions.
Equity	Risk of exposure to road traffic noise is not equally distributed.
Resource use and implications	No comprehensive cost–effectiveness analysis data are available; nevertheless, a wide range of solutions exists and several are being implemented, showing that effective interventions are both feasible and economically reasonable.
Decisions on recommendation strength	• **Strong** for guideline level for average noise exposure (L_{den}) • **Strong** for guideline value for average night noise exposure (L_{night}) • **Strong** for specific interventions to reduce noise exposure

3.2 Railway noise

Recommendations

For average noise exposure, the GDG **strongly** recommends reducing noise levels produced by railway traffic below **54 dB** L_{den}, as railway noise above this level is associated with adverse health effects.

For night noise exposure, the GDG **strongly** recommends reducing noise levels produced by railway traffic during night time below **44 dB** L_{night}, as railway noise above this level is associated with adverse effects on sleep.

To reduce health effects, the GDG **strongly** recommends that policy-makers implement suitable measures to reduce noise exposure from railways in the population exposed to levels above the guideline values for average and night noise exposure. There is, however, insufficient evidence to recommend one type of intervention over another.

3.2.1 Rationale for the guideline levels for railway noise

The exposure levels were derived in accordance with the prioritizing process of critical health outcomes described in section 2.4.3. For each of the outcomes, the exposure level was identified by applying the benchmark, set as relevant risk increase to the corresponding ERF. In the case of exposure to railway noise, the process can be summarized as follows (Table 16).

Table 16. Average exposure levels (L_{den}) for priority health outcomes from railway noise

Summary of priority health outcome evidence	Benchmark level	Evidence quality
Incidence of IHD No studies were available and therefore incidence of IHD could not be used to assess the exposure level.	5% increase of RR	No studies met the inclusion criteria/no studies available
Incidence of hypertension One study met the inclusion criteria. There was no significant increase of risk associated with increased noise exposure in this study.	10% increase of RR	Low quality
Prevalence of highly annoyed population There was an absolute risk of 10% at a noise exposure level of 53.7 dB L_{den}.	10% absolute risk	Moderate quality
Permanent hearing impairment	No increase	No studies met the inclusion criteria/no studies available
Reading skills and oral comprehension in children	One-month delay	No studies met the inclusion criteria/no studies available

In accordance with the prioritization process (see section 2.4.3), the GDG set a guideline exposure level of 53.7 dB L_{den} for average exposure, based on the relevant increase of the absolute %HA. In accordance with the defined rounding procedure, the value was rounded to 54 dB L_{den}. As the evidence on the adverse effects of railway noise was rated moderate quality, the GDG made the recommendation strong.

Next, the GDG assessed the evidence for night noise exposure and its effect on sleep disturbance (Table 17).

Table 17. Night-time exposure levels (L_{night}) for priority health outcomes from railway noise

Summary of priority health outcome evidence	Benchmark level	Evidence quality
Sleep disturbance 3% of the participants in studies were highly sleep-disturbed at a noise level of **43.7 dB** L_{night}	3% absolute risk	Moderate quality

Based on the evidence of the adverse effects of railway noise on sleep disturbance, the GDG defined a guideline exposure level of 43.7 dB L_{night}. The exact exposure value was rounded to 44 dB L_{night}. As the evidence was rated moderate quality, the GDG made the recommendation strong.

The GDG also considered the evidence for the effectiveness of interventions. The results showed that:

- intervening at the source by applying rail grinding procedures can reduce noise annoyance;
- behavioural interventions such as informing the community about noise interventions can reduce noise annoyance.

In light of the strong evidence about the adverse health effects, the GDG followed a precautionary approach and made a strong recommendation for interventions on railway noise, as it was confident that interventions are realizable and that best practices already exist for the management of noise from railways. Since the empirical evidence on the effectiveness of different types of intervention was rated either low or very low quality, the GDG felt that no recommendation could be made on the preferred type of intervention, and agreed not to recommend any specific type of intervention over another.

3.2.1.1 Other factors influencing the strength of recommendations

Other factors considered in the context of recommendations on railway noise included those related to values and preferences, benefits and harms, resource implications, equity, acceptability and feasibility; moreover, nonpriority health outcomes were considered. The assessment of all these factors – especially the values and preferences involved in railway noise – did not lead to a change in the strength of the recommendations. Further details are provided in Section 3.2.2.3.

3.2.2 Detailed overview of the evidence

The following sections provide a detailed overview of the evidence constituting the basis for setting the recommendations on railway noise. It is presented and summarized separately for each of the critical health outcomes, and the GDG's judgement of the quality of evidence is indicated (for a detailed overview of the evidence on important health outcomes, see Annex 4). Research into health outcomes and effectiveness of interventions is addressed consecutively.

A comprehensive summary of all evidence considered for each of the critical and important health outcomes can be found in the eight systematic reviews published in the *International Journal of Environmental Research and Public Health* (see section 2.3.2 and Annex 2).

3.2.2.1 Evidence on health outcomes

The key question posed was: in the general population exposed to railway noise, what is the exposure–response relationship between exposure to railway noise (reported as various noise indicators) and the proportion of people with a validated measure of health outcome, when adjusted for main confounders? A summary of the PICOS/PECCOS scheme applied and the main findings is set out in Tables 18 and 19.

Table 18. PICOS/PECCOS scheme of critical health outcomes for exposure to railway noise

PECO	Description	
Population	General population	
Exposure	Exposure to high levels of noise produced by railway traffic (average/night time)	
Comparison	Exposure to lower levels of noise produced by railway traffic (average/night time)	
Outcome(s)	For average noise exposure: 1. cardiovascular disease 2. annoyance 3. cognitive impairment 4. hearing impairment and tinnitus 5. adverse birth outcomes 6. quality of life, well-being and mental health 7. metabolic outcomes	For night noise exposure: 1. effects on sleep

Table 19. Summary of findings for health effects from exposure to railway noise (L_{den})

Noise metric	Priority health outcome measure	Quantitative risk for adverse health	Lowest level of exposure across studies	Number of participants (studies)[a]	Quality of evidence
Cardiovascular disease					
L_{den}	Incidence of IHD	–	–	–	–
L_{den}	Incidence of hypertension	RR = 0.96 (95% CI: 0.88–1.04) per 10 dB increase	N/A	7249 (1)	Low (downgraded for risk of bias and availability of only one study)
Annoyance					
L_{den}	%HA	OR = 3.53 (95% CI: 2.83–4.39) per 10 dB increase	34	10 970 (10)	Moderate (downgraded for inconsistency, directness; upgraded for dose-response)
Cognitive impairment					
L_{den}	Reading and oral comprehension	–	–	–	–
Hearing impairment and tinnitus					
L_{den}	Permanent hearing impairment	–	–	–	–

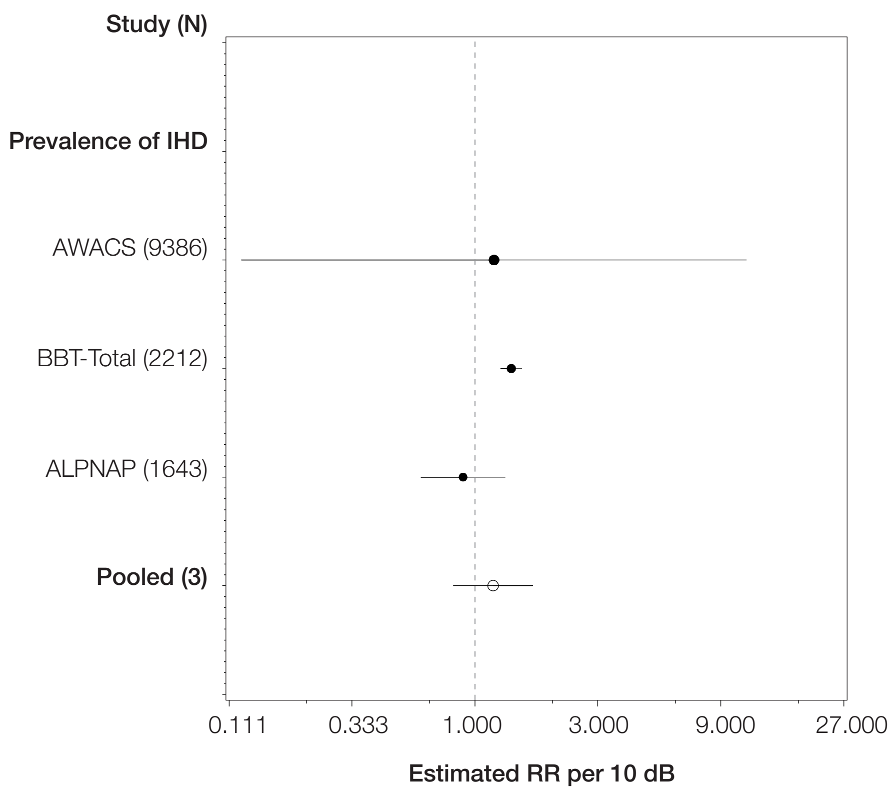
Note: [a] Results are partly derived from population-based studies.

Cardiovascular disease

IHD

No evidence was available on the relationship between railway noise and the incidence of or mortality from IHD. Four cross-sectional studies were identified, however, that assessed the prevalence of IHD in a total of 13 241 participants, including 283 cases (Heimann et al., 2007; Lercher et al., 2008; 2011; van Poll et al., 2014). The overall risk was not statistically significantly increased: the RR was 1.18 (95% CI: 0.82–1.68) per 10 dB L_{den} increase, with inconsistency across studies (see Fig. 7). The evidence was rated very low quality.

Fig. 7. The association between exposure to railway noise (L_{den}) and prevalence of IHD



Notes: The dotted vertical line corresponds to no effect of exposure to railway noise. The black circles correspond to the estimated RR per 10 dB and 95% CI. The white circle represents the pooled random effect estimates and 95% CI. For further details on the studies included in the figure please refer to the systematic review on environmental noise and cardiovascular and metabolic effects (van Kempen et al., 2018).

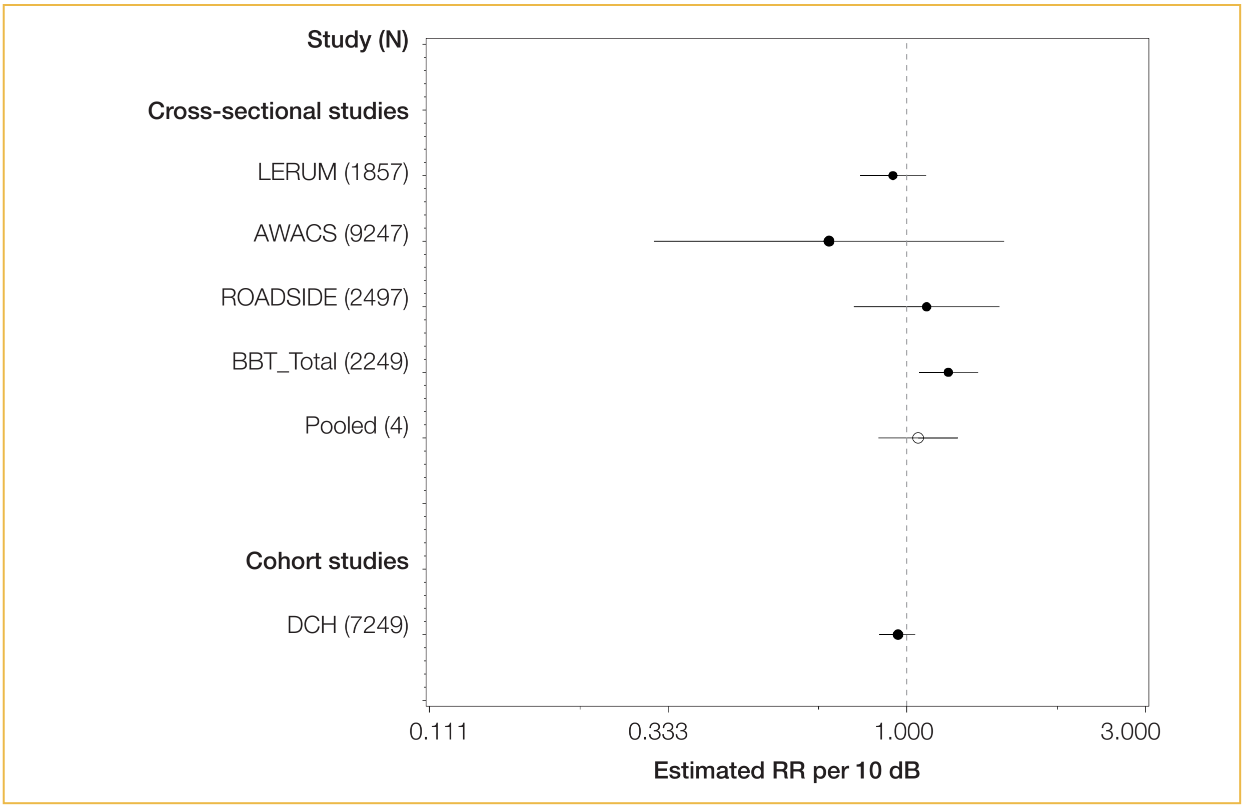
Hypertension

One cohort study on the relationship between railway noise and hypertension was identified; it assessed the incidence among people living in Denmark (Sörensen et al., 2011; 2012a). The study involved 7249 participants, including 3145 cases. The authors did not find an association between railway noise exposure and incidence of hypertension, with RR = 0.96 (95% CI: 0.88–1.04) per 10 dB L_{den} increase. This evidence was rated low quality.

In addition, five cross-sectional studies assessed the prevalence of hypertension in 15 850 participants, including 2059 cases (Barregard et al., 2009; Eriksson et al., 2012; Lercher et al., 2008; 2011; van Poll et al., 2014). The overall RR increase was not statistically significant, at 1.05 (95% CI: 0.88–1.26) per 10 dB L_{den} increase. Moreover, there was inconsistency among the results across studies. The evidence was rated very low quality.

Fig. 8 presents the studies investigating the relationship between railway noise and different measures of hypertension.

Fig. 8. The association between exposure to railway noise (L_{den}) and hypertension



Notes: The dotted vertical line corresponds to no effect of exposure to railway noise. The black dots correspond to the estimated RR per 10 dB and 95% CI. The white circle represents the summary estimate and 95% CI.
For further details on the studies included in the figure please refer to the systematic review on environmental noise and cardiovascular and metabolic effects (van Kempen et al., 2018).

Stroke

As for IHD, no evidence was available on the relationship between railway noise and incidence of or mortality from stroke. However, one cross-sectional study was identified that assessed the prevalence of stroke in 9365 participants, including 89 cases (van Poll et al., 2014). The overall risk was not statistically significantly increased, with RR = 1.07 (95% CI: 0.92–1.25) per 10 dB L_{den} increase. The evidence was rated very low quality.

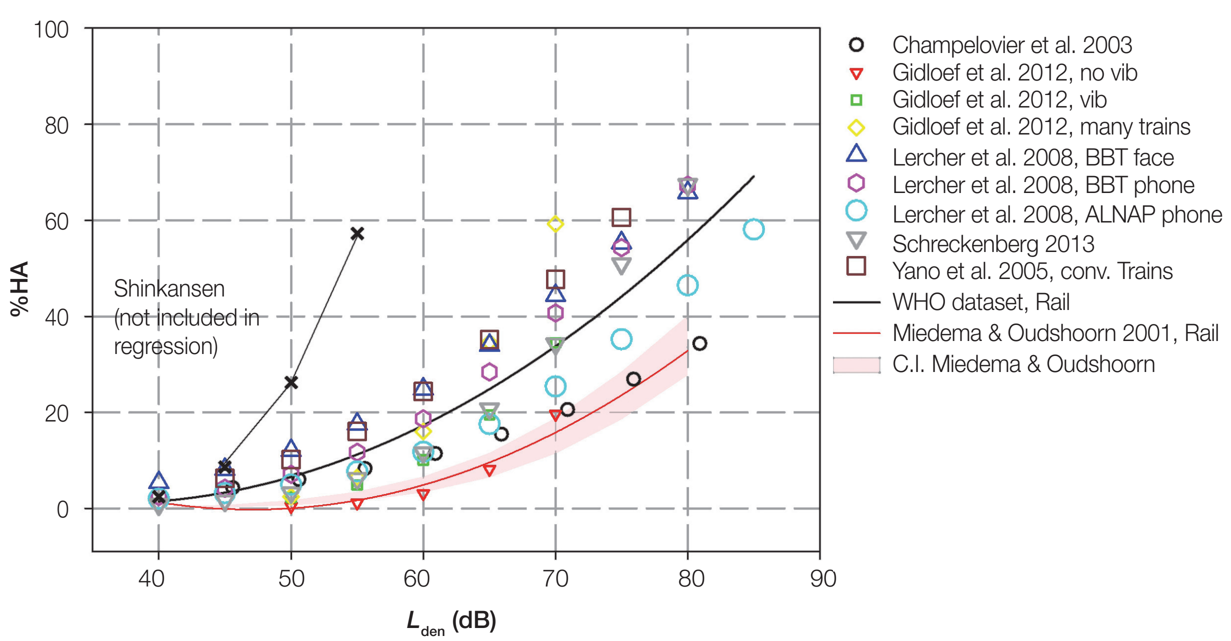
Children's blood pressure

No evidence was available for the association between railway noise and the systolic and/or diastolic blood pressure of children in residential and/or educational settings.

Annoyance

In total, 10 studies with ERFs on the association between railway noise and annoyance were included in analyses (Champelovier et al., 2003; Gidloef-Gunnarsson et al., 2012; Lercher et al., 2007; 2008; Sato et al., 2004; Schreckenberg, 2013; Yano et al., 2005; Yokoshima et al., 2008). The studies incorporated individual data from 10 970 participants. The estimated data points of each of these studies are plotted in Fig. 9, alongside an aggregated ERF including the data from all the individual studies (see the black line for "WHO dataset, Rail"). The lowest category of noise exposure considered in any of the studies, and hence included in the systematic review is 40 dB, corresponding to approximately 1.5%HA. The 10% benchmark for %HA is reached at 53.7 dB L_{den} (see Fig. 9).

Fig. 9. Scatterplot and quadratic regression of the relationship between railway noise (L_{den}) and annoyance (%HA)



Notes: The ERF by Miedema & Oudshoorn (2001) is added in red for comparison.
There is no indication of 95% CIs of the WHO dataset curve, as a weighting based on the total number of participants for each 5 dB L_{den} sound class could not be calculated; weighting based on all participants of all sound classes proved to be unsuitable. The range of data included is illustrated by the distribution of data points.
For further details on the studies included in the figure please refer to the systematic review on environmental noise and annoyance (Guski et al., 2017).

Table 20 shows the %HA for railway noise exposure. The calculations are based on the regression equation %HA = 38.1596–2.05538 × L_{den} + 0.0285 × $L_{den}{}^2$ derived from the systematic review (Guski et al., 2017). The overall evidence was rated moderate quality. Additional statistical analyses of annoyance outcomes supported these findings. When comparing railway noise exposure at 50 dB and 60 dB, the analyses revealed evidence rated moderate quality for an association between railway noise and %HA for an increase per 10 dB (OR = 3.40; 95% CI: 2.05–5.62). Moreover, evidence rated high quality was available for the increase in %HA per 10 dB increase in sound exposure, when data on all sound classes were included (OR = 3.53; 95% CI: 2.83–4.39).

Table 20. The association between exposure to railway noise (L_{den}) and annoyance (%HA)

L_{den} (dB)	%HA
40	1.5
45	3.4
50	6.6
55	11.3
60	17.4
65	25.0
70	33.9
75	44.3
80	56.1

Cognitive impairment

Studies of railway noise on children's reading and oral comprehension were lacking. Nevertheless, other measures of cognition yielded evidence rated very low quality for an association between railway noise and children with poorer performance on standardized assessment tests (Bronzaft, 1981; Bronzaft & McCarthy, 1975). Evidence for the association between railway noise and children having poorer long-term memory (Lercher et al., 2003) was rated very low quality. No studies examined effects on short-term memory.

There was no clear relation between railway noise and attention in children (Lercher et al., 2003), and this evidence was rated very low quality.

Hearing impairment and tinnitus

No studies were found, and therefore no evidence was available on the association between railway noise and hearing impairment and tinnitus.

Sleep disturbance

For railway noise and self-reported sleep outcomes (awakenings from sleep, the process of falling asleep and sleep disturbance), five studies were identified that included a total of 7133 participants (Bodin et al., 2015; Hong et al., 2010; Sato et al., 2004; Schreckenberg, 2013). The studies were cross-sectional and conducted on healthy adults. The health outcome was measured by self-reporting via general health surveys and noise surveys that included questions about sleep in general, and other questions about how noise affects sleep (Table 21).

Table 21. Summary of findings for health effects from exposure to railway noise (L_{night})

Noise metric	Priority health outcome measure	Quantitative risk for adverse health	Lowest level of exposure across studies	Number of participants (studies)	Quality of evidence
Effects on sleep					
L_{night}	%HSD	OR: 3.06 (95% CI: 2.38–3.93) per 10 dB increase	33 dB	7133 (5)	Moderate (downgraded for study limitations, inconsistency; upgraded for dose-response, magnitude of effect)

The model in the systematic review (Basner & McGuire, 2018) was based on outdoor L_{night} levels between 40 dB and 65 dB only; 40 dB was chosen as the lower limit because of possible inaccuracies in predicting lower noise levels. The range of noise exposure reported in the studies was 27.5–82.5 dB L_{night}. About 2% (95% CI: 0.79–3.48) of the population was characterized as highly sleep-disturbed for L_{night} levels of 40 dB. The %HSD at other, higher levels of railway noise is presented in Table 17. The association between railway noise and the probability of being sleep-disturbed was OR: 3.1 (95% CI: 2.4–3.9) per 10 dB increase in noise. This evidence was rated moderate quality.

Table 22. The association between exposure to railway noise (L_{night}) and sleep disturbance (%HSD)

L_{night} (dB)	%HSD	95% CI
40	2.1	0.79–3.48
45	3.7	1.63–5.71
50	6.3	3.12–9.37
55	10.4	5.61–15.26
60	17.0	9.48–24.37
65	26.3	15.20–37.33

Additional analyses were conducted for sleep quality measures, which provided supporting evidence on the overall relationship between railway noise and sleep. When the noise source was not specified in the question, the relationship between railway noise and self-reported sleep outcomes was still positive but no longer statistically significant, with an OR of 1.27 (95% CI: 0.89–1.81) per 10 dB increase (Bodin et al., 2015; Brink, 2011; Frei et al., 2014). This evidence was rated very low quality.

There was evidence rated moderate quality for an association between railway noise and the probability of additional awakenings, measured with polysomnography, with an OR of 1.35 (95% CI: 1.21–1.52) per 10 dB increase in indoor $L_{AS,max}$ (Elmenhorst et al., 2012). Finally, evidence rated low quality was available for an association between railway noise and sleep outcomes measured as motility in adults (Griefahn et al., 2000; Hong et al., 2006; Lercher et al., 2010; Passchier-Vermeer et al., 2007), and rated very low quality for an association between railway noise and both self-reported and motility-measured sleep disturbance in children (Ising & Ising, 2002; Lercher et al., 2013; Tiesler et al., 2013).

3.2.2.2 Evidence on interventions

This section summarizes the evidence underlying the recommendation on the effectiveness of interventions for railway noise exposure (Tables 23 and 24). The key question posed was: in the general population exposed to railway noise, are interventions effective in reducing exposure to and/ or health outcomes from railway noise? A summary of the PICOS/PECCOS scheme applied and the main findings is set out in Tables 23 and 24.

Table 23. PICOS/PECCOS scheme of the effectiveness of interventions for exposure to railway noise

PICO	Description	
Population	**General population**	
Intervention(s)	The interventions can be defined as: (a) a measure that aims to change noise exposure and associated health effects; (b) a measure that aims to change noise exposure, with no particular evaluation of the impact on health; or (c) a measure designed to reduce health effects, but that may not include a reduction in noise exposure.	
Comparison	**No intervention**	
Outcome(s)	For average noise exposure: 1. cardiovascular disease 2. annoyance 3. cognitive impairment 4. hearing impairment and tinnitus 5. adverse birth outcomes 6. quality of life, well-being and mental health 7. metabolic outcomes	For night noise exposure: 1. effects on sleep

Table 24. Summary of findings for railway noise interventions by health outcome

Type of intervention	Number of participants (studies)	Effect of intervention	Quality of evidence
Annoyance			
Type A – source interventions (rail grinding)	81 (1)	• Changes in noise level as a consequence of the intervention ranged from around −7dB to −8 dB. • Most studies found changes in annoyance outcomes, persisting more than 12 months after the intervention.	Very low (downgraded for study limitations, inconsistency, imprecision)
Type C – changes in infrastructure (new rail infrastructure)	6000[a] (1)	• A very small increase in total noise exposure was found (most had <+1 dB change; some had +2–4 dB change). • Original noise from road traffic overwhelmed the train noise for effectively all participants.	Very low (downgraded for study limitations, inconsistency, imprecision)
Type E – behaviour change interventions (informing the community about a noise intervention)	411 (1)	• Exposure levels were not reported; emission levels reduced by 1–2 dB. • A reduction in annoyance of the community as a result of the intervention was reported.	Very low (downgraded for study limitations, inconsistency, imprecision)

Note: [a] According to Lam & Au (2008), this records the number of invitation letters sent; the response rate was not reported.

Three studies on railway noise interventions met the criteria to be included in the evidence base. All studies consisted of a pre/post design and reported annoyance outcomes at people's dwellings (Lam & Au, 2008; Moehler et al., 1997; Schreckenberg et al., 2013). They could be categorized as a source intervention, a new/closed infrastructure intervention and a communication intervention. In two of the studies, the changes in exposure after the intervention were only small, although there were significant effects on noise annoyance. The study on source interventions and annoyance revealed that a change of –10 dB in noise exposure led to a significant reduction in annoyance, which persisted over a period of 12 months after the intervention. As confounding was not addressed, and railway noise was not the dominant sound source in the studies, the evidence was rated very low quality.

3.2.2.3 Consideration of additional contextual factors

As the foregoing overview has shown, sufficient evidence about the adverse health effects of long-term exposure to railway noise exists. Based on the quality of the available evidence, the GDG set the strength of recommendation on railway noise at strong. As a second step, it qualitatively assessed contextual factors to explore whether other considerations could have a relevant impact on the recommendation strength. These contextual considerations mainly concerned the balance of harms and benefits, values and preferences, and resource use and implementation.

When assessing the balance of harms and benefits of interventions to reduce exposure to railway noise and minimize noise-associated adverse health effects, the GDG recognized that railway transportation is the second most dominant source of environmental noise in Europe. Based on EEA estimates, the number of people exposed to L_{den} above 55 dB and L_{night} above 50 dB from railway noise is 17 million and 15 million, respectively (Blanes et al., 2017).[15] In light of the burden of disease from environmental noise, and railway noise in particular, the GDG agreed that the health benefits from a reduction of long-term railway noise exposure (especially during night time) to the recommended values would be significant. Considering possible harms related to adaptation of the recommended values, the GDG noted that reliance on railway transportation has increased in recent years in Europe and is expected to increase further, as an important component of the shift towards a greener economy. At a societal level, an environmental and economic benefit from the use of rail transportation is expected: trains contribute to lower environmental pollution and carbon emission than road transportation. Therefore, there is a need to balance the expected health benefits from reduced continuous railway noise exposure and the overall positive effects on the health of the population from increased reliance on the comparatively environmentally friendly mode of railway transportation. Overall, the GDG agreed that even though fewer people are exposed to railway noise than road traffic noise, it remains a major source of localized noise pollution; therefore, considerable benefits are gained by reducing exposure to railway noise.

When exploring values and preferences, the GDG acknowledged that, in general, people value rail as an alternative and more sustainable transportation method than air or road traffic (EEA, 2016a; 2016b; 2017b). Furthermore, the values and preferences in relation to implementation of the recommendation are expected to vary: those of individuals living in the vicinity of railway tracks are expected to differ from those of the rest of the population not exposed to railway noise on a long-term basis. Economic depreciation of housing and fear of adverse health effects were assumed

[15] These are gap-filled figures based on the reported data and including the situation both within and outside cities, as defined by the END.

to be two main aspects influencing the evaluation of affected individuals. This especially applies to areas where new railway tracks are being built, as this results in considerable change for local inhabitants. Moreover, the GDG acknowledged that preferences might also vary in the policy-making domain across different countries as the implementation of the recommendations would mean a renunciation of the so-called "railway bonus".[16]

On resource use and implementation considerations, the GDG pointed out that no comprehensive cost–benefit analysis for the WHO European Region has yet been conducted, so this assessment is based on informed qualitative expert judgement regarding the feasibility of implementing the recommendation for the majority of the population. The systematic review of environmental noise interventions and their associated impact on health shows that various measures to reduce continuous noise from railway traffic exist, although knowledge about their effectiveness remains limited (Brown & van Kamp, 2017). The GDG noted that the resources needed to implement different measures may vary considerably, as they depend on the situation and the type of intervention required. Implementation of some measures is expected to be most feasible during the development of new railway tracks; such as rail pads, bi-bloc sleepers, small noise barriers and – in extreme cases – tunnels, cuttings or earthwork barriers. Other interventions include acoustic rail grinding, noise barriers built alongside the tracks, construction of quieter locomotives and wagons and replacement of brakes on freight trains. The GDG assumed that most of these solutions could be planned as part of regular maintenance or, for instance, by speeding up fleet modernization and track modernization. Even though not broadly implemented, the solutions mentioned above have already been considered or adopted to reduce noise levels from railway noise exposure. Some EU countries (such as Germany), have programmes to replace old brake blocks from freight trains with newer, quieter ones and to ban all freight trains with old brake blocks from 2020 (Umweltbundesamt, 2017). This illustrates that solutions to achieve recommended noise levels can be implemented at a reasonable cost. Overall, the GDG agreed that the benefit of implementation of the recommendation to minimize the risk of adverse health effects due to railway noise for a majority of the population exceeds the (monetary) resources needed.

In light of the assessment of the contextual factors in addition to the quality of evidence, the recommendation remains strong.

Additional considerations or uncertainties

The GDG acknowledged that the main body of evidence for the recommendations on railway noise for average exposure was based on annoyance studies, conducted mainly in Asia and Europe. Studies are few for other priority health outcomes, and the evidence was generally rated low/very low quality. There is therefore uncertainty about the effects on health outcomes. Nevertheless, as a precautionary approach, a strong recommendation is made for average exposure to L_{den}, as a broad evidence base exists for health effects from exposure to other sources of transportation noise. However, the GDG stressed the importance of further research into health effects due to long-term exposure to railway noise.

Moreover, situational factors should be taken into account when analysing annoyance from railway noise. In particular, ground-borne vibrations are sometimes an additional exposure variable in railway

[16] The "railway bonus" is a correction factor commonly applied in the noise abatement policy domain in recent decades. It subsidizes the noise rating level for railway transportation by a predefined factor (Schuemer & Schuemer-Kohrs, 1991).

noise situations – especially in the case of annoyance – which may be difficult to separate from noise effects. In the set of 11 studies included in the systematic review on railway noise and annoyance, only two explicitly mentioned ground-borne vibrations as an additional source of annoyance.

Overall, the low-carbon, low-polluting nature of railway transport, especially using electric trains, means that rail is favoured over road and air traffic. However, night-time railway traffic on busy lines, including freight traffic, can be a significant source of sleep disturbance. Thus, guideline values should be set to encourage the development of rail traffic in Europe while at the same time giving adequate protection to residents from sleep disturbance.

3.2.3 Summary of the assessment of the strength of the recommendations

Table 25 provides a comprehensive summary of the different dimensions for the assessment of the strength of the railway noise recommendations.

Table 25. Summary of the assessment of the strength of the recommendation

Factors influencing the strength of recommendation	Decision
Quality of evidence	**Average exposure** (L_{den}) *Health effects* • Evidence for a relevant absolute risk of annoyance at **54 dB** L_{den} was rated **moderate quality.** • Evidence for a relevant RR increase of the incidence of hypertension was rated **low quality**. One study met the inclusion criteria but did not find a significant increase. *Interventions* • Evidence that different types of intervention reduce noise annoyance from railways was rated **very low quality**. **Night-time exposure** (L_{night}) *Health effects* • Evidence for a relevant absolute risk of sleep disturbance related to night noise exposure from railways at **44 dB** L_{night} was rated **moderate quality**. *Interventions* • No evidence was available on the effectiveness of interventions to reduce noise exposure and/or sleep disturbance from railway noise.
Balance of benefits versus harms and burdens	Railway noise is a major source of localized pollution. The health benefits of adapting the recommendation outweigh the harms. Nevertheless, it is important to consider the relevance of railways as an environmentally friendly mode of transportation.
Values and preferences	Quiet areas are valued by the population; especially by those affected by continuous noise exposure. Some variability is expected among those directly affected by railway noise and those not affected.
Resource implications	No comprehensive cost–effectiveness-analysis data are available, although a wide range of interventions exists, indicating that measures are both feasible and economically reasonable.
Decisions on recommendation strength	• **Strong** for guideline value for average noise exposure (L_{den}). • **Strong** for guideline value for night noise exposure (L_{night}). • **Strong** for specific interventions to reduce noise exposure.

3.3 Aircraft noise

Recommendations

For average noise exposure, the GDG **strongly** recommends reducing noise levels produced by aircraft below **45 dB** L_{den}, as aircraft noise above this level is associated with adverse health effects.

For night noise exposure, the GDG **strongly** recommends reducing noise levels produced by aircraft during night time below **40 dB** L_{night}, as aircraft noise above this level is associated with adverse effects on sleep.

To reduce health effects, the GDG strongly recommends that policy-makers implement suitable measures to reduce noise exposure from aircraft in the population exposed to levels above the guideline values for average and night noise exposure. For specific interventions the GDG recommends implementing suitable changes in infrastructure.

3.3.1 Rationale for the guideline levels for aircraft noise

The exposure levels were derived in accordance with the prioritization process of critical health outcomes described in section 2.4.3. For each of the outcomes, the exposure level was identified by applying the benchmark, set as relevant risk increase to the corresponding ERF. In the case of exposure to aircraft noise, the process can be summarized as follows (Table 26).

Table 26. Average exposure levels (L_{den}) for priority health outcomes from aircraft noise

Summary of priority health outcome evidence	Benchmark level	Evidence quality
Incidence of IHD A relevant risk increase from exposure to aircraft noise occurs at 52.6 dB L_{den}. The weighted average of the lowest noise levels measured in the studies was 47 dB L_{den} and the corresponding RR in the meta-analysis was 1.09 per 10 dB.	5% increase of RR	Very low quality
Incidence of hypertension One study met the inclusion criteria. There was no significant increase of risk associated with increased noise exposure in this study.	10% increase of RR	Low quality
Prevalence of highly annoyed population There was an absolute risk of 10% at a noise exposure level of 45.4 dB L_{den}.	10% absolute risk	Moderate quality
Permanent hearing impairment	No increase	No studies met the inclusion criteria
Reading skills and oral comprehension in children A relevant risk increase was found at 55 dB L_{den}.	One-month delay	Moderate quality

Based on the evaluation of evidence on relevant risk increases from the prioritized health outcomes, the GDG set a guideline exposure level of 45.4 dB L_{den} for average exposure to aircraft noise, based on the absolute %HA. It was confident that there was an increased risk for annoyance below this exposure level, but probably no relevant risk increase for other priority health outcomes. In accordance with the defined rounding procedure, the value was rounded to 45 dB L_{den}. As the evidence on the adverse effects of aircraft noise was rated moderate quality, the GDG made the recommendation strong.

Next, the GDG considered the evidence for night noise exposure and its effect on sleep disturbance (Table 27).

Table 27. Night-time exposure levels (L_{night}) for priority health outcomes from aircraft noise

Summary of priority health outcome evidence	Benchmark level	Evidence quality
Sleep disturbance	3% absolute risk	Moderate quality
11% of participants were highly sleep-disturbed at a noise level of 40 dB L_{night}.		

Based on the evidence of the adverse effects of aircraft noise on sleep disturbance, the GDG defined a guideline exposure level of 40.0 dB L_{night}. It should be stressed that this recommendation for average aircraft noise levels at night far exceeds the benchmark of 3%HSD defined as relevant risk increase, but since no reliable acoustic data below this level were available, the GDG decided not to lower the guideline exposure level further, as an extrapolation of the exposure–response relationship to achieve these values would have been unavoidable. As the evidence was rated moderate quality, the GDG made the recommendation strong.

The GDG also considered the evidence for the effectiveness of interventions. The results showed that changes in infrastructure (opening and/or closing of runways, or flight path rearrangements) can lead to a reduction in aircraft noise exposure, as well as a decline in cognitive impairment in children and a reduction in annoyance. Moreover, examples of best practice already exist for the management of noise from aircraft, so the GDG made a strong recommendation.

3.3.1.1 Other factors influencing the strength of recommendations

Other factors considered in the context of recommendations on aircraft traffic noise included those related to values and preferences, benefits and harms, resource implications, equity, acceptability and feasibility; moreover, nonpriority health outcomes were considered. Ultimately, the assessment of all these factors did not lead to a change in the strength of the recommendations. Further details are provided in section 3.3.2.3.

3.3.2 Detailed overview of the evidence

The following sections provide a detailed overview of the evidence constituting the basis for setting the recommendations on aircraft noise. It is presented and summarized separately for each of the critical health outcomes, and the GDG's judgement of the quality of evidence is indicated (for a detailed overview of the evidence on important health outcomes, see Annex 4). Research into health outcomes and effectiveness of interventions is addressed consecutively.

A comprehensive summary of all evidence considered for each of the critical and important health outcomes can be found in the eight systematic reviews published in the *International Journal of Environmental Research and Public Health* (see section 2.3.2 and Annex 2).

3.3.2.1 Evidence on health outcomes

The key question posed was: in the general population exposed to aircraft noise, what is the exposure–response relationship between exposure to aircraft noise (reported as various noise indicators) and the proportion of people with a validated measure of health outcome, when adjusted for main confounders? A summary of the PICOS/PECCOS scheme applied and the main findings is set out in Tables 28 and 29.

Table 28. PICOS/PECCOS scheme of critical health outcomes for exposure to aircraft noise

PECO	Description	
Population	General population	
Exposure	Exposure to high levels of noise produced by aircraft traffic (average/night time)	
Comparison	Exposure to lower levels of noise produced by aircraft traffic (average/night time)	
Outcome(s)	For average noise exposure: 1. cardiovascular disease 2. annoyance 3. cognitive impairment 4. hearing impairment and tinnitus 5. adverse birth outcomes 6. quality of life, well-being and mental health 7. metabolic outcomes	For night noise exposure: 1. effects on sleep

Table 29 .Summary of findings for health effects from exposure to aircraft noise (L_{den})

Noise metric	Priority health outcome measure	Quantitative risk for adverse health	Lowest level of exposure across studies	Number of participants (studies)[a]	Quality of evidence
Cardiovascular disease					
L_{den}	Incidence of IHD	RR = 1.09 (95% CI: 1.04–1.15) per 10 dB increase	47 dB	9 619 082[a] (2)	Very low (downgraded for risk of bias; upgraded for dose-response)
L_{den}	Incidence of hypertension	RR = 1.00 (95% CI: 0.77–1.30) per 10 dB increase	N/A	4712 (1)	Low (downgraded for risk of bias and because only one study available)
Annoyance					
L_{den}	%HA	OR = 4.78 (95% CI: 2.27–10.05) per 10 dB increase	33 dB	17 094 (12)	Moderate (downgraded for inconsistency)
Cognitive impairment					
L_{den}	Reading and oral comprehension	1–2-month delay per 5 dB increase	Around 55 dB	(4)	Moderate (downgraded for inconsistency)
Hearing impairment and tinnitus					
L_{den}	Permanent hearing impairment	–	–	–	–

Note: [a] Results are partly derived from population-based studies.

Cardiovascular disease

IHD

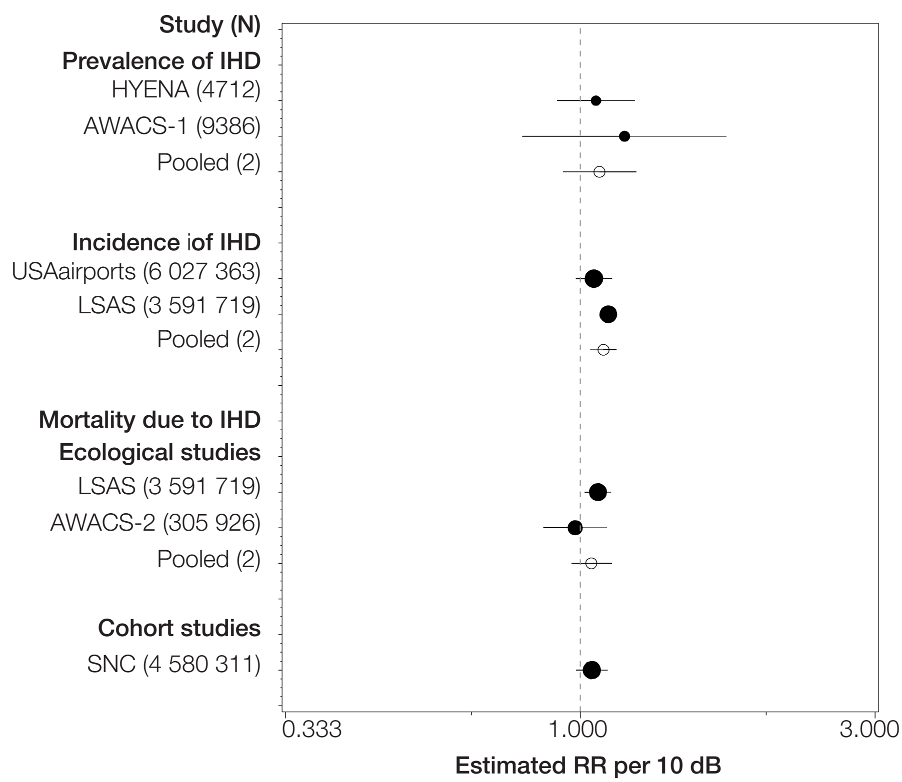
No cohort or case-control studies on the relationship between aircraft noise and IHD are available. However, two ecological studies were identified that provide information on the relationship between aircraft noise and incidence (hospital admission) of IHD (Correia et al., 2013; Hansell et al., 2013). These involved a total of 9 619 082 participants, including 158 977 cases. The RR was 1.09 (95% CI: 1.04–1.15) per 10 dB L_{den} increase, and the lowest exposure range was ≤51 dB and <45 dB. Given the weights in the meta-analysis of these two studies, the weighted average starting level was calculated as 47 dB. The evidence was rated very low quality.

Two cross-sectional studies were identified that assessed the prevalence of IHD in people living in cities located around airports in Europe. The studies involved 14 098 participants, including 340 cases (Babisch et al., 2005b; 2008; 2012a; 2012b; 2013a; Floud et al., 2011; 2013a; 2013b; Jarup et al., 2005; 2008; van Poll et al., 2014). The overall risk was RR = 1.07 (95% CI: 0.94–1.23) per 10 dB L_{den} increase. The evidence was rated low quality.

With regard to the relationship between aircraft noise and mortality due to IHD, one cohort study (Huss et al., 2010) and two ecological studies (Hansell et al., 2013; van Poll et al., 2014) were identified. The cohort study identified 4 580 311 participants, including 15 532 cases, living in Switzerland, and the authors found an RR of 1.04 (95% CI: 0.98–1.11) per 10 dB L_{den} increase in noise. The evidence was rated low quality. The two ecological studies identified a total of 3 897 645 participants, including 26 066 cases in the Netherlands and the United Kingdom. The overall RR was 1.04 (95% CI: 0.97–1.12) per 10 dB L_{den} increase in noise, and the evidence was rated very low quality.

Fig. 10 summarizes the results for the relationship between aircraft noise and different measures of IHD.

Fig. 10. The association between exposure to aircraft noise (L_{den}) and IHD



Notes: The dotted vertical line corresponds to no effect of exposure to aircraft noise. The black circles correspond to the estimated RR per 10 dB and 95% CI. The white circles represent the pooled random effect estimates and 95% CI. For further details on the studies included in the figure please refer to the systematic review on environmental noise and cardiovascular and metabolic effects (van Kempen et al., 2018).

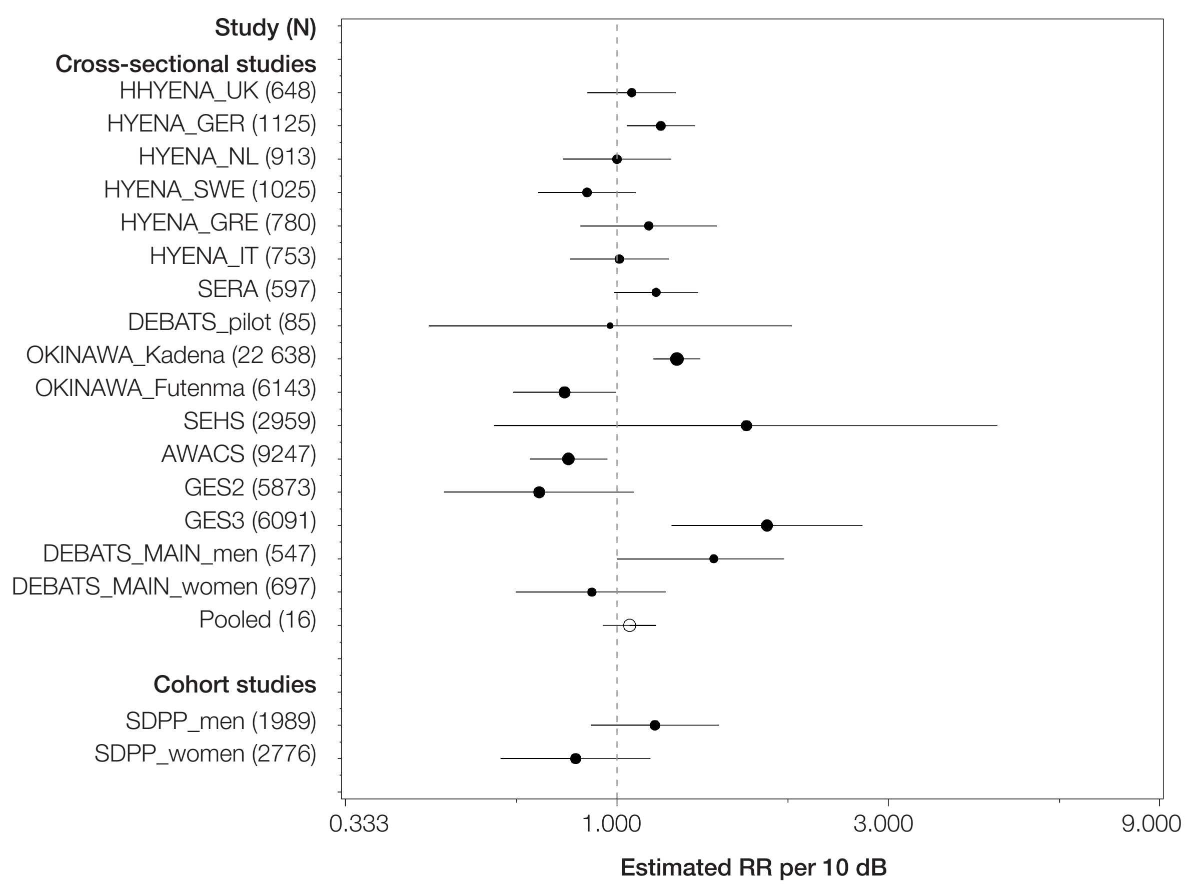
Hypertension

One cohort study was identified that assessed the relationship between aircraft noise and hypertension in people living in Sweden (Bluhm et al., 2004; 2009; Eriksson et al., 2007; 2010). The study involved 4712 participants, including 1346 cases. The authors found a nonstatistically significant effect size of RR = 1.00 (95% CI: 0.77–1.30) per 10 dB L_{den} increase. This evidence was rated moderate quality.

Furthermore, nine cross-sectional studies assessed the prevalence of hypertension in 60 121 participants, including 9487 cases (Ancona et al., 2010; Babisch et al., 2005b; 2008; 2012a; 2012b; 2013a; Breugelmans et al., 2004; Evrard et al., 2013; 2015; Houthuijs & van Wiechen, 2006; Jarup et al., 2005; 2008; Matsui, 2013; Matsui et al., 2001; 2004; Rosenlund et al., 2001; van Kamp et al., 2006; van Poll et al., 2014). The overall RR was 1.05 (95% CI: 0.95–1.17) per 10 dB L_{den} increase, with inconsistency across studies. The evidence was rated low quality.

Fig. 11 summarizes the results for both prevalence and incidence of hypertension.

Fig. 11. The association between exposure to aircraft noise (L_{den}) and hypertension in cross-sectional and cohort studies



Notes: The dotted vertical line corresponds to no effect of aircraft noise exposure. The black dots correspond to the estimated RR per 10 dB and 95% CI. The white circle represents the pooled summary estimate and 95% CI. For further details on the studies included in the figure please refer to the systematic review on environmental noise and cardiovascular and metabolic effects (van Kempen et al., 2018).

Stroke

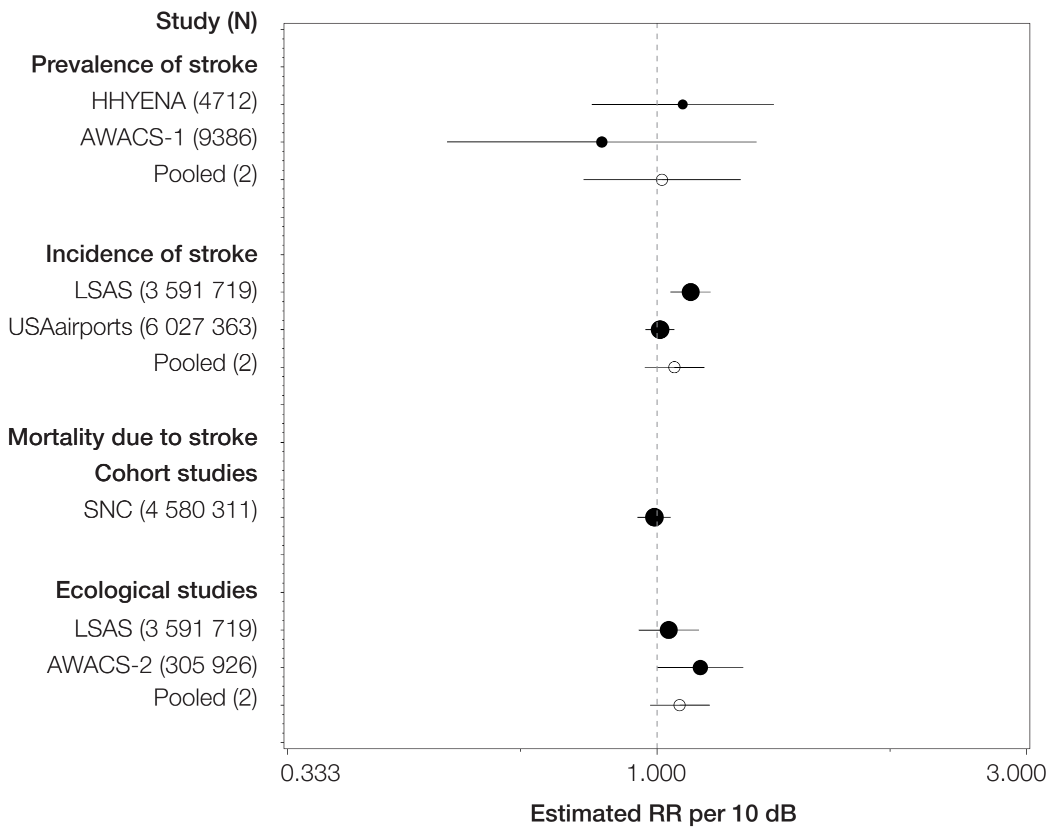
No cohort or case-control studies on the relationship between aircraft noise and incidence (hospital admission) of stroke were available, but two ecological studies were conducted in cities around airports in the United Kingdom and United States of America, involving 9 619 082 participants, including 97 949 cases (Correia et al., 2013; Hansell et al., 2013). An overall RR of 1.05 (95% CI: 0.96–1.15) per 10 dB L_{den} increase in noise was found. The evidence was rated very low quality.

Two cross-sectional studies were identified that assessed the prevalence of stroke in 14 098 participants, including 151 cases (Babisch et al., 2005b; 2008; 2012a; 2012b; 2013a; Floud et al., 2011; 2013a; 2013b; Jarup et al., 2005; 2008; van Poll et al., 2014). The overall RR was 1.02 (95% CI: 0.80–1.28) per 10 dB L_{den} increase. The evidence was rated very low quality.

On the relationship between aircraft noise and mortality due to stroke, one cohort study (Huss et al., 2010) and two ecological studies (Hansell et al., 2013; van Poll et al., 2014) were identified. The cohort study identified 4 580 311 participants, including 25 231 cases, living in Switzerland; the authors found an RR of 0.99 (95% CI: 0.94–1.04) per 10 dB L_{den} increase in noise. The overall evidence was rated moderate quality. The two ecological studies identified a total of 3 897 645 participants, including 12 086 cases, in the Netherlands and the United Kingdom. The overall RR was 1.07 (95% CI: 0.98–1.17) per 10 dB L_{den} increase in noise. The evidence was rated very low quality.

Fig. 12 summarizes the results for the relationship between aircraft noise and different measures of stroke.

Fig. 12. The association between exposure to aircraft noise (L_{den}) and stroke



Notes: The dotted vertical line corresponds to no effect of exposure to aircraft noise. The black dots correspond to the estimated RR per 10 dB and 95% CI. The white circle represents the summary estimate and 95% CI.
For further details on the studies included in the figure please refer to the systematic review on environmental noise and cardiovascular and metabolic effects (van Kempen et al., 2018).

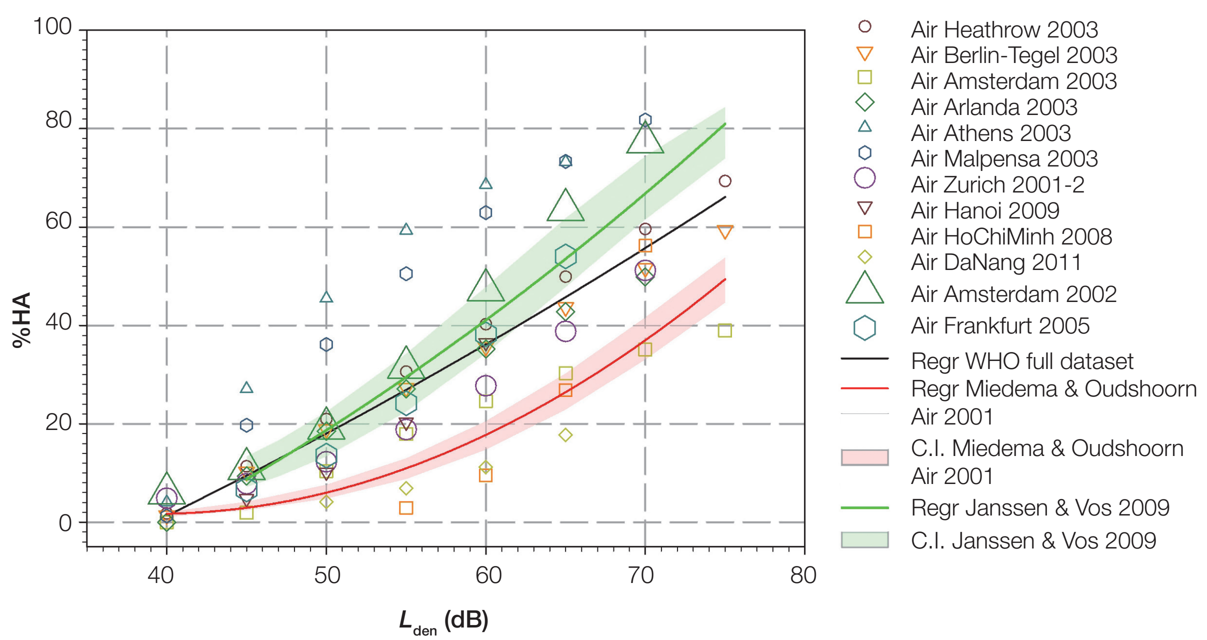
Children's blood pressure

For the association between aircraft noise and blood pressure in children, two cross-sectional studies were conducted in Australia, the Netherlands and the United Kingdom, including a total of 2013 participants (Clark et al., 2012; Morrell et al., 1998; 2000; van Kempen et al., 2006). The change in both systolic and diastolic blood pressure was assessed, in residential and/or educational settings. There was serious inconsistency in the results and therefore no overall estimate of the effect was developed. The evidence was rated very low quality.

Annoyance

A vast amount of evidence proves the association between aircraft noise and annoyance. In total, 12 aircraft noise studies were identified that were used to model ERFs of the relationship between L_{den} and %HA (Babisch et al., 2009; Bartels et al., 2013; Breugelmans et al., 2004; Brink et al., 2008; Gelderblom et al., 2014; Nguyen et al., 2011; 2012a; 2012b; Sato & Yano, 2011; Schreckenberg & Meis, 2007). These include data from 17 094 study participants. The estimated data points of each of the studies are plotted in Fig. 13, alongside an aggregated ERF including the data from all the individual studies (see the black line for "Regr WHO full dataset"). The lowest category of noise exposure considered in any of the studies, and hence included in the systematic review, is 40 dB, corresponding to approximately 1.2%HA. The benchmark level of 10%HA is reached at approximately 45 dB L_{den} (see Fig. 13).

Fig. 13. Scatterplot and quadratic regression of the relationship between aircraft noise (L_{den}) and annoyance (%HA)



Notes: ERFs by Miedema & Oudshoorn (2001, red), and Janssen & Vos (2009, green) are added for comparison. There is no indication of 95% CIs of the WHO dataset curve, as a weighting based on the total number of participants for each 5 dB L_{den} sound class could not be calculated; weighting based on all participants of all sound classes proved to be unsuitable. The range of data included is illustrated by the distribution of data points. For further details on the studies included in the figure please refer to the systematic review on environmental noise and annoyance (Guski et al., 2017).

Table 30 shows the %HA in relation to exposure to aircraft traffic noise. It is based on the regression equation %HA = −50.9693 + 1.0168 × L_{den} + 0.0072 × L_{den}^{2} derived from the systematic review (Guski et al., 2017). As the majority of the studies are cross-sectional, the evidence was rated moderate quality.

The general quality of the evidence was further substantiated with the help of additional statistical analyses that apply classical health outcome measures to estimate noise annoyance. When comparing aircraft noise exposure at 50 dB and 60 dB, the analyses revealed evidence rated high quality for an association between aircraft noise and %HA for an increase per 10 dB (OR = 3.40; 95% CI: 2.42–4.80). Moreover, there was evidence rated high quality for the increase of %HA per 10 dB increase in sound exposure, when data on all sound classes were included (OR = 4.78; 95% CI: 2.27–10.05).

Table 30. The association between exposure to aircraft noise (L_{den}) and annoyance (%HA)

L_{den} (dB)	%HA
40	1.2
45	9.4
50	17.9
55	26.7
60	36.0
65	45.5
70	55.5

Cognitive impairment

Evidence rated moderate quality was available for an association between aircraft noise and reading and oral comprehension, assessed by standardized tests. This is based on a narrative review of 14 studies that examined aircraft noise exposure effects on reading and oral comprehension (Clark et al., 2006; 2012; 2013; Evans & Maxwell, 1997; Haines et al., 2001a; 2001b; 2001c; Hygge et al., 2002; Klatte et al., 2014; Matsui et al., 2004; Seabi et al., 2012; 2013; Stansfeld et al., 2005; 2010). Of these studies, 10 were cross-sectional, and only four had a longitudinal and/or intervention design (Clark et al., 2013; Haines et al., 2001c; Hygge et al., 2002; Seabi et al., 2013). Most of the studies (10 of 14) demonstrated a statistically significant association or at least demonstrated a trend between higher aircraft noise exposure and poorer reading comprehension.

This relationship is supported by evidence on other health outcome measures related to cognition. Evidence rated moderate quality was available for an association between aircraft noise and children with poorer performance on standardized assessment tests (Eagan et al., 2004; FICAN, 2007; Green et al., 1982; Sharp et al., 2014). There was also evidence rated moderate quality on aircraft noise being associated with children having poorer long-term memory (Haines et al., 2001b). No studies examined the effects on short-term memory.

However, there was no substantial effect (evidence rated low quality) of aircraft noise on children's attention (Haines et al., 2001a; Hygge et al., 2002; Matsui et al., 2004; Stansfeld et al., 2005; 2010), or on executive function (working memory) (evidence rated very low quality), with studies consistently suggesting no association for aircraft noise (Clark et al., 2012; Haines et al., 2001a;

Haines et al., 2001b; Klatte et al., 2014; Matheson et al., 2010; Stansfeld et al., 2005; 2010; van Kempen et al., 2010; 2012).

Hearing impairment and tinnitus

No studies were found, and therefore no evidence was available on the association between aircraft noise and hearing impairment and tinnitus.

Sleep disturbance

For aircraft noise and self-reported sleep outcomes, six studies were identified that included a total of 6371 participants (Nguyen et al., 2009; 2010; 2011; 2012c; 2015; Schreckenberg et al., 2009; Yano et al., 2015). The majority of studies were cross-sectional by design and were conducted in otherwise healthy adults. The model was based on outdoor L_{night} levels between 40 dB and 65 dB only; the lower limit of 40 dB was set because of inaccuracies in predicting lower noise levels (Table 31).

Table 31. Summary of findings for health effects from exposure to aircraft noise (L_{night})

Noise metric	Priority health outcome measure	Quantitative risk for adverse health	Lowest level of exposure across studies	Number of participants (studies)	Quality of evidence
Effects on sleep					
L_{night}	%HSD	OR: 1.94 (95% CI: 1.61–2.33) per 10 dB increase	35 dB	6371 (6)	Moderate (downgraded for study limitations, inconsistency; upgraded for dose-response, magnitude of effect)

The range of noise exposure reported in studies was 37.5–62.5 dB. Over 11% (95% CI: 4.72–17.81) of the population was characterized as highly sleep-disturbed at L_{night} levels of 40 dB. The %HSD at other, higher levels of aircraft noise is presented in Table 27. The table is derived from the regression model in the systematic review specified as %HSD = 16.79–0.9293 × L_{night} + 0.0198 × L_{night}^2. The health outcome was measured in the studies by self-reporting, focusing on questions asking about awakenings from sleep, the process of falling asleep and/or sleep disturbance, where the question referred specifically to how noise affects sleep. The same relationship between aircraft noise and reporting being sleep-disturbed (all questions combined) can also be expressed as an OR of 1.94 (95% CI: 1.61–2.33) per 10 dB increase in noise. This evidence was rated moderate quality.

Table 32. The association between exposure to aircraft noise (L_{night}) and sleep disturbance (%HSD)

L_{night}	%HSD	95% CI
40	11.3	4.72–17.81
45	15.0	6.95–23.08
50	19.7	9.87–29.60
55	25.5	13.57–37.41
60	32.3	18.15–46.36
65	40.0	23.65–56.05

Additional analyses were included in the systematic review and provided supporting evidence on the association between aircraft noise and sleep. When the noise source was not specified in the survey question, the relationship between aircraft noise and self-reported sleep outcomes was still positive, although no longer statistically significant (OR: 1.17 (95% CI: 0.54–2.53) per 10 dB increase) (Brink, 2011). This evidence was rated very low quality.

Further, there was evidence rated moderate quality for an association between aircraft noise and polysomnography-measured outcomes (probability of additional awakenings), with an OR of 1.35 (95% CI: 1.22–1.50) per 10 dB increase in indoor $L_{AS,max}$ (Basner et al., 2006). Evidence rated low quality was also available for an association between aircraft noise and motility-measured sleep outcomes in adults (Passchier-Vermeer et al., 2002).

3.3.2.2 Evidence on interventions

The following section summarizes the evidence underlying the recommendation on the effectiveness of interventions for aircraft noise exposure. The key question posed was: in the general population exposed to aircraft noise, are interventions effective in reducing exposure to and/or health outcomes from aircraft noise? A summary of the PICOS/PECCOS scheme applied and the main findings is set out in Tables 33 and 34.

Seven studies examining different types of interventions on aircraft noise met the inclusion criteria to become part of the evidence base of the systematic review. Six of these investigated infrastructure interventions (Breugelmans et al., 2007; Brink et al., 2008; Fidell et al., 2002; Hygge et al., 2002), and one assessed a path intervention (Asensio et al., 2014). The majority of studies focused on annoyance as a health outcome, but two also included effects on sleep and one investigated the effects of path interventions on cognitive development in children.

Table 33. PICOS/PECCOS scheme of the effectiveness of interventions for exposure to aircraft noise

PICO	Description	
Population	**General population**	
Intervention(s)	The interventions can be defined as: (a) a measure that aims to change noise exposure and associated health effects; (b) a measure that aims to change noise exposure, with no particular evaluation of the impact on health; or (c) a measure designed to reduce health effects, but that may not include a reduction in noise exposure.	
Comparison	**No intervention**	
Outcome(s)	For average noise exposure: 1. cardiovascular disease 2. annoyance 3. cognitive impairment 4. hearing impairment and tinnitus 5. adverse birth outcomes 6. quality of life, well-being and mental health 7. metabolic outcomes	For night noise exposure: 1. effects on sleep

Table 34. Summary of findings for aircraft noise interventions by health outcome

Type of intervention	Number of participants (studies)	Effect of intervention	Quality of evidence
Annoyance			
Type B – path interventions (retrofitting dwellings close to airports with acoustic insulation)	689 (1)	• Change in noise levels was not reported. • The study found a drop in annoyance following the insulation intervention	Very low (downgraded for study limitations, inconsistency, precision)
Type C – changes in infrastructure (opening and/or closing of runways, or flight path rearrangements)	2101 (3)	• There was a wide range of changes in noise levels (from –12 dB to +13.7 dB; most between ±1 dB and 2 dB; different noise indicators used). • All studies found changes in annoyance outcomes as a result of the intervention.	Moderate (downgraded for study limitations; upgraded for dose-response)
Sleep disturbance			
Type C – changes in infrastructure (flight path changes)	1707 (2)	• Changes in noise levels were mostly between ±1 dB and 2 dB. • Both studies found changes in sleep disturbance outcomes as a result of the intervention.	Low (downgraded for study limitations)
Cognitive development of children			
Type C – changes in infrastructure (opening and/or closing of runways, or flight path rearrangements)	326 (1)	• Changes in noise levels of +9 dB at the new airport and of –14 dB at the old airport were reported. • The study found various cognitive effects on children (for both the reduction and the increase in exposure). Effects disappeared when the old airport closed, emerging after the new airport opened.	Moderate (downgraded for inconsistency)

The largest body of research concentrated on the opening and closing of runways, leading to subsequent changes in flight paths (Breugelmans et al., 2007; Brink et al., 2008; Fidell et al., 2002). It showed that changes in noise exposure as a consequence of rearrangement of flight paths, step changes or increase or removal of over-flights resulted in statistically significant changes of the annoyance ratings of residents living in the vicinity of airports. The studies investigated both increases and reductions in exposure. Moreover, all the studies provided evidence that the change in response to noise exposure was an excess response to the intervention. As all the studies either adjusted for confounding or ruled out confounding by design, and the risk of bias was high in two studies but low in one, the evidence was rated moderate quality.

Two of these studies also investigated the effects of interventions on sleep disturbance. The results indicated that the percentage of sleep disturbance changed in association with the change in noise exposure caused by flight path adaptations (Breugelmans et al., 2007; Fidell et al., 2002). Both studies adjusted for confounding, but the risk of bias was assessed as high. Thus, the evidence was rated low quality.

One study examined the impact of rearranging flight paths on the cognitive effects on children (Hygge et al., 2002), showing various effects (for both the reduction and the increase in exposure).

The study ruled out confounding by study design and the risk of bias was assessed as low. The evidence was therefore rated moderate quality.

Alongside infrastructure interventions, a Spanish study presented evidence on path interventions (Asensio et al., 2014), showing a drop in annoyance following an insulation intervention. The study did not control for confounding and the risk of bias was assessed as high. The evidence was therefore rated very low quality.

3.3.2.3 Consideration of additional contextual factors

As the foregoing overview has shown, substantial evidence about the adverse health effects of long-term exposure to aircraft noise exists. Based on the quality of the available evidence, the GDG set the strength of the recommendation of aircraft noise at strong. As a second step, it qualitatively assessed contextual factors to explore whether other considerations could have a relevant impact on the recommendation strength. These considerations mainly concerned the balance of harms and benefits, values and preferences, equity, and resource use and implementation.

When assessing the balance of harms and benefits from implementing the recommendations on aircraft exposure, the GDG acknowledged that the number of people affected was lower than for road traffic or railway noise, since aircraft noise only affects the areas surrounding airports and under flight paths. Data from the EEA show that the estimated number of people in Europe exposed to L_{den} levels above 55 dB and L_{night} levels above 50 dB is 3 million and 1.2 million, respectively (Blanes et al., 2017).[17] Nevertheless, it remains a major source of localized noise pollution and has been predicted to increase (EASA et al., 2016). Furthermore, aircraft noise is regarded as more annoying than the other sources of transportation noise (Schreckenberg et al., 2015; Miedema & Oudshoorn, 2001); it is therefore associated with a significant burden on public health, and the GDG expects substantial health benefits for the population to evolve from implementing the recommendations to reduce exposure to aircraft traffic noise. Furthermore, the GDG noted that, depending on the intervention measure implemented (such as a night flight ban), additional health benefits could evolve, resulting from a simultaneous reduction in air pollution (EC, 2016a). The GDG also acknowledged that intervention measures like night flight bans might also reduce carbon emission, thereby positively influencing the shift towards a greener and more sustainable economy. Possible harms in relation to the applied noise abatement strategy, on the other hand, could include effects on the transportation of goods, as well as individual mobility of the population. Both could have impacts on local, national and international economies. Overall, the GDG estimated that the benefits gained from minimizing adverse health effects due to aircraft noise exposure outweigh the possible (economic) harms.

Considering values and preferences, the GDG noted that negative attitudes towards aircraft noise are especially prevalent in affected individuals who can see and hear aircraft from their house, or who fear that living in proximity of airports will have an impact on their health (Schreckenberg et al., 2015) or property value (economic loss) (Bristow et al., 2014). A lack of trust in the airport and government authorities can enhance these negative attitudes towards airports and aircraft noise (Borsky, 1979; Schreckenberg, 2017). Furthermore, the GDG recognized that values and preferences of individuals living in the vicinity of different airports may vary, as the infrastructural characteristics

[17] These are gap-filled figures based on the reported data and including the situation both within and outside cities, as defined by the END.

of airports have a significant effect on the evaluation of residents. Airports with a stable number of aircraft movements in the near past and no intention to change the number in the future can give rise to a different evaluation of values and preferences than airports with relatively sustained increases in the number of aircraft movements. This can result from the fact that opening new runways or increasing the number of flights usually means considerable change in the environment for inhabitants of the affected area. It has been postulated that the change of exposure itself may be an annoying factor, and this may explain why aircraft noise annoyance is generally higher than that for other sources of transportation noise at a comparable noise level (Brown & van Kamp, 2009). The GDG acknowledged that, in general, air travel is an important means of transportation relevant for businesses, the public and the economy. In Europe, aviation is projected to be the fastest-growing sector from passenger transport demand, by 2050 (EEA, 2016a). The general population tends to value the convenience of travel by air. Moreover, the GDG pointed out that exposure to aircraft noise is not equally distributed throughout society. The preferences of people living in the vicinity of airports are expected to differ from those of the general population that does not experience the same noise burden. This might facilitate variance in the values and preference of the population, as those benefiting from the services and revenues generated by an airport may regard noise reduction measures as an additional, unnecessary extra cost, while those living around an airport and affected by aircraft noise may be in favour of noise reductions, since this concerns their health and well-being. Despite these differences, however, the GDG was confident that a majority of the population would value the minimization of adverse health effects and therefor welcome the implementation of the recommendations.

Regarding the dimension of equity, the GDG highlighted that the risk of exposure to aircraft noise is not equally distributed throughout society. Members of society with a lower socioeconomic status and other disadvantaged groups often live in more polluted and louder areas, including in close proximity to airports (EC, 2016a). In addition to the increased risk of exposure to environmental noise, socioeconomic factors are also associated with increased vulnerability and poorer coping capacities (Karpati et al., 2002).

With resource use and implementation considerations, the GDG acknowledged that the economic evaluation of the health impacts of environmental noise is most elaborate and extensive for aircraft noise (Berry & Sanchez, 2014). Nevertheless, no comprehensive cost–benefit analysis for the WHO European Region yet exists, so this assessment is based on informed qualitative expert judgement regarding the feasibility of implementing the recommendation for the majority of the population. The systematic review of interventions and their associated impact on environmental noise and health shows that various measures to reduce continuous noise from aircraft exist. Moreover, the quality of the evidence was judged to be moderate (Brown & van Kamp, 2017). The GDG noted that the resources needed to implement different intervention measures may vary considerably, because they depend on the situation and the type of intervention required. The distribution of costs also differs from that for other modes of transportation, since exposure to aircraft noise is localized in a more agglomerated way, and overall the population affected is smaller compared to other modes of transportation. The GDG furthermore recognized that multiple cost-effective intervention strategies exist (EC, 2016b). Prohibition or discouragement strategies against citizens moving to the direct proximity of airports, for example, can be implemented in the context of urban planning. Likewise, diverting flight paths above less-populated areas can lead to a reduction in exposure. In principle, such intervention measures do not involve any direct costs, although safety concerns may limit the feasibility of these strategies. Passive noise abatement measures like the installation of soundproof windows at the dwelling were also regarded as feasible and economically reasonable by the GDG, as these are implemented at several airports already. In relation to active abatement measures, the GDG acknowledged the "balanced approach" elaborated by International Civil Aviation Organization, which states that noise reduction should take place first at the source. As indicated by the Clean Sky Programme, this could, for example, entail shifting towards the introduction of new aircraft. This broad European research programme estimates that, depending on type, the shift to newly produced aircraft could lead to a reduction of approximately 55–79% of the area affected by aircraft noise, and consequently the population exposed. As this solution has been put forward by the aviation sector, it is considered feasible. Overall, this indicates that solutions to achieve recommended noise levels can be implemented and at reasonable costs. The GDG agreed that implementation of the recommendation to minimize the risk of adverse health effects due to aircraft noise for a majority of the population would require a reasonable amount of (monetary) resources. It noted, however, that the feasibility of implementing the measures could be hindered by the fact that costs and benefits are not equally distributed. In most cases, the health benefits citizens gain from interventions that reduce aircraft exposure are borne by private companies and public authorities.

In light of the assessment of the contextual factors in addition to the quality of evidence, the recommendation remains strong.

Other nonpriority adverse health outcomes

Although not a priority health outcome and coming from a single study, the GDG noted the evidence rated moderate quality for the statistically significant association between aircraft noise and the change in waist circumference (Eriksson et al., 2014). The range of noise levels in the study identified was 48 to 65 dB L_{den}, and therefore the recommendation would also be protective enough for this health outcome.

In the context of aircraft noise, when considering the impacts of exposure on cognitive impairment in children, these guideline recommendations also apply particularly to the school setting. Noise exposure at primary school and at home is often highly correlated; however, the evidence base considered comes mainly from studies designed around sampling at school and not residences.

Additional considerations or uncertainties

There is additional uncertainty when characterizing exposure using the acoustical description of aircraft noise by means of L_{den} or L_{night}. Use of these average noise indicators may limit the ability to observe associations between exposure to aircraft noise and some health outcomes (such as awakening reactions); as such, noise indicators based on the number of events (such as the frequency distribution of $L_{A,max}$) may be better suited. However, such indicators are not widely used.

The GDG acknowledged that the guideline recommendation for L_{night} may not be fully protective of health, as it implies that around 11% (95% CI: 4.72–17.81) of the population may be characterized as highly sleep-disturbed at the recommended L_{night} level. This is higher than the 3% absolute risk considered for setting the guideline level. However, the high calculation uncertainty in predicting noise levels lower than 40 dB prevented the GDG from recommending a lower level. Furthermore, lower levels would probably require a ban on night or early morning flights altogether, which is not feasible in many situations, given that the general population tends to value the convenience of air travel.

3.3.3 Summary of the assessment of the strength of recommendation

Table 35 provides a comprehensive summary of the different dimensions for the assessment of the strength of the aircraft noise recommendations.

Table 35. Summary of the assessment of the strength of the recommendation

Factors influencing the strength of recommendation	Decision
Quality of evidence	**Average exposure (L_{den})** *Health effects* • Evidence for a relevant RR increase of the incidence of IHD at **52 dB** L_{den} was rated **very low quality.** • Evidence for a relevant RR increase of the incidence of hypertension was rated **low quality**. • Evidence for a relevant absolute risk of annoyance at **45 dB** L_{den} was rated **moderate quality**. • Evidence for a relevant RR increase of impaired reading and oral comprehension at **55 dB L_{den}** was rated **moderate quality**. *Interventions* • Evidence on effectiveness of interventions to reduce noise exposure and/or health outcomes from aircraft noise was of varying quality. **Night-time exposure (L_{night})** *Health effects* • Evidence for a relevant absolute risk of sleep disturbance related to night noise exposure from aircraft at **40 dB** L_{night} was rated **moderate quality**. *Interventions* • Evidence on effectiveness of changes in infrastructure (flight path changes) to reduce sleep disturbance from aircraft noise was rated **low quality**.
Balance of benefits versus harms and burdens	Aircraft noise is a major source of localized noise pollution. The health benefits of adapting the recommendations are expected to outweigh the harms.
Values and preferences	Quiet areas are valued by the population, especially by those affected by continuous aircraft noise exposure. Some variability is expected among those directly affected by aircraft noise and those not affected.
Equity	Risk of exposure to aircraft noise is not equally distributed.
Resource implications	No comprehensive cost–effectiveness analysis data are available; nevertheless, a wide variety of interventions exist (some at very low cost), indicating that measures are both feasible and economically reasonable.
Decisions on recommendation strength	• **Strong** for guideline value for average noise exposure (L_{den}) • **Strong** for guideline value for night noise exposure (L_{night}) • **Strong** for specific interventions to reduce noise exposure

3.4 Wind turbine noise

Recommendations

For average noise exposure, the GDG **conditionally** recommends reducing noise levels produced by wind turbines below **45 dB** L_{den}, as wind turbine noise above this level is associated with adverse health effects.

To reduce health effects, the GDG **conditionally** recommends that policy-makers implement suitable measures to reduce noise exposure from wind turbines in the population exposed to levels above the guideline values for average noise exposure. No evidence is available, however, to facilitate the recommendation of one particular type of intervention over another.

3.4.1 Rationale for the guideline levels for wind turbine noise

The exposure levels were derived in accordance with the prioritizing process of critical health outcomes described in section 2.4.3. For each of the outcomes, the exposure level was identified by applying the benchmark, set as relevant risk increase to the corresponding ERF. In the case of exposure to wind turbine noise, the process can be summarized as follows (Table 36).

Table 36. Average exposure levels (L_{den}) for priority health outcomes from wind turbine noise

Summary of priority health outcome evidence	Benchmark level	Evidence quality
Incidence of IHD Incidence of IHD could not be used to assess the exposure level.	5% increase of RR	No studies were available
Incidence of hypertension Incidence of hypertension could not be used to assess the exposure level.	10% increase of RR	No studies were available
Prevalence of highly annoyed population Four studies were available. An exposure–response curve of the four studies revealed an absolute risk of 10%HA (outdoors) at a noise exposure level of 45 dB L_{den}.	10% absolute risk	Low quality
Permanent hearing impairment	No increase	No studies were available
Reading skills and oral comprehension in children	One-month delay	No studies were available

In accordance with the prioritization process, the GDG set a guideline exposure level of 45.0 dB L_{den} for average exposure, based on the relevant increase of the absolute %HA. The GDG stressed that there might be an increased risk for annoyance below this noise exposure level, but it could not state whether there was an increased risk for the other health outcomes below this level owing to a lack of evidence. As the evidence on the adverse effects of wind turbine noise was rated low quality, the GDG made the recommendation conditional.

Next, the GDG considered the evidence for night noise exposure to wind turbine noise and its effect on sleep disturbance (Table 37).

Table 37. Night-time exposure levels (L_{night}) for priority health outcomes from wind turbine noise

Summary of priority health outcome evidence	Benchmark level	Evidence quality
Sleep disturbance Six studies were available; they did not reveal consistent results about effects of wind turbine noise on sleep.	3% absolute risk	Low quality

Based on the low quantity and heterogeneous nature of the evidence, the GDG was not able to formulate a recommendation addressing sleep disturbance due to wind turbine noise at night time.

The GDG also looked for evidence about the effectiveness of interventions for wind turbine noise exposure. Owing to a lack of research, however, no studies were available on existing interventions and associated costs to reduce wind turbine noise.

Based on this assessment, the GDG therefore provided a conditional recommendation for average noise exposure (L_{den}) to wind turbines and a conditional recommendation for the implementation of suitable measures to reduce noise exposure. No recommendation about a preferred type of intervention could be formulated; nor could a recommendation be made for an exposure level for night noise exposure (L_{night}), as studies were not consistent and in general did not provide evidence for an effect on sleep.

3.4.1.1 Other factors influencing the strength of recommendation

Other factors considered in the context of recommendations on wind turbine noise included those related to values and preferences, benefits and harms, resource implications, equity, acceptability and feasibility. Ultimately, the assessment of all these factors did not lead to a change in the strength of recommendation, although it informed the development of a conditional recommendation on the intervention measures. Further details are provided in section 3.4.2.3.

3.4.2 Detailed overview of the evidence

The following sections provide a detailed overview of the evidence constituting the basis for setting the recommendations on wind turbine noise. It is presented and summarized separately for each of the critical health outcomes, and the GDG's judgement of the quality of evidence is indicated (for a detailed overview of the evidence on important health outcomes, see Annex 4). Research into health outcomes and effectiveness of intervention is addressed consecutively.

A comprehensive summary of all evidence considered for each of the critical and important health outcomes can be found in the eight systematic reviews published in the *International Journal of Environmental Research and Public Health* (see section 2.3.2 and Annex 2).

It should be noted that, due to the time stamp of the systematic reviews, some more recent studies were not included in the analysis. This relates in particular to several findings of the Wind Turbine Noise and Health Study conducted by Health Canada (Michaud, 2015). Further, some studies were omitted, as they did not meet the inclusion criteria, including, for instance, studies using distance to the wind turbine instead of noise exposure to investigate health effects. The justification for including and excluding studies is given in the systematic reviews (Basner & McGuire, 2018; Brown et al., 2017; Clark & Paunovic, 2018; in press; Guski et al., 2017; Niewenhuijsen et al.,2017; Śliwińska-Kowalska & Zaborowski, 2017; van Kempen et al., 2018; see Annex 2 for further details).

3.4.2.1 Evidence on health outcomes

The key question posed was: in the general population exposed to wind turbine noise, what is the exposure–response relationship between exposure to wind turbine noise (reported as various noise indicators) and the proportion of people with a validated measure of health outcome, when adjusted for main confounders? A summary of the PICOS/PECCOS scheme applied and the main findings is set out in Tables 38 and 39.

Table 38. PICOS/PECCOS scheme of critical health outcomes for exposure to wind turbine noise

PECO	Description	
Population	General population	
Exposure	Exposure to high levels of noise produced by wind turbines (average/night time)	
Comparison	Exposure to lower levels of noise produced by wind turbines (average/night time)	
Outcome(s)	For average noise exposure: 1. cardiovascular disease 2. annoyance 3. cognitive impairment 4. hearing impairment and tinnitus 5. adverse birth outcomes 6. quality of life, well-being and mental health 7. metabolic outcomes	For night noise exposure: 1. effects on sleep

Table 39. Summary of findings for health effects from exposure to wind turbine noise (L_{den})

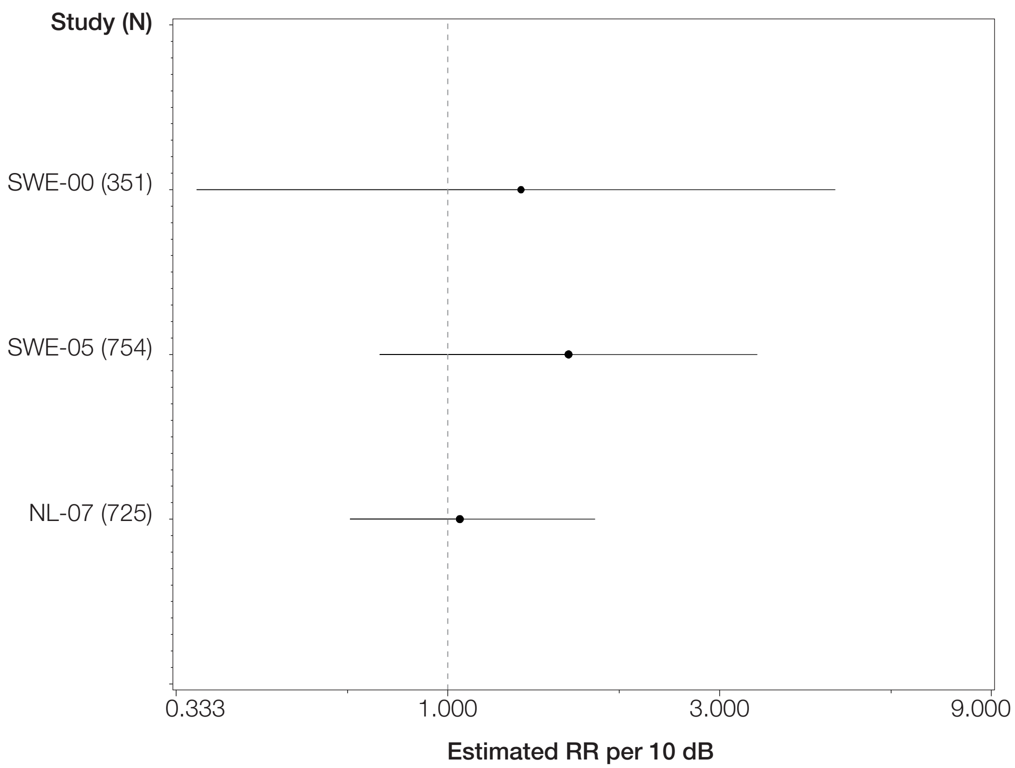
Noise metric	Priority health outcome measure	Quantitative risk for adverse health	Lowest level of exposure across studies	Number of participants (studies)	Quality of evidence
Cardiovascular disease					
L_{den}	Incidence of IHD	–	–	–	–
L_{den}	Incidence of hypertension	–	–	–	–
Annoyance					
L_{den}	%HA	Not able to pool because of heterogeneity	30 dB	2481 (4)	Low (downgraded for inconsistency and imprecision)
Cognitive impairment					
L_{den}	Reading and oral comprehension	–	–	–	–
Hearing impairment and tinnitus					
L_{den}	Permanent hearing impairment	–	–	–	–

Cardiovascular disease

For the relationship between wind turbine noise and prevalence of hypertension, three cross-sectional studies were identified, with a total of 1830 participants (van den Berg et al., 2008; Pedersen, 2011; Pedersen & Larsman, 2008; Pedersen & Persson Waye, 2004; 2007). The number of cases was not reported. All studies found a positive association between exposure to wind turbine noise and the prevalence of hypertension, but none was statistically significant. The lowest levels in studies were either <30 or <32.5 L_{den}. No meta-analysis was performed, since too many parameters were unknown and/or unclear. Due to very serious risk of bias and imprecision in the results, this evidence was rated very low quality (see Fig. 14).

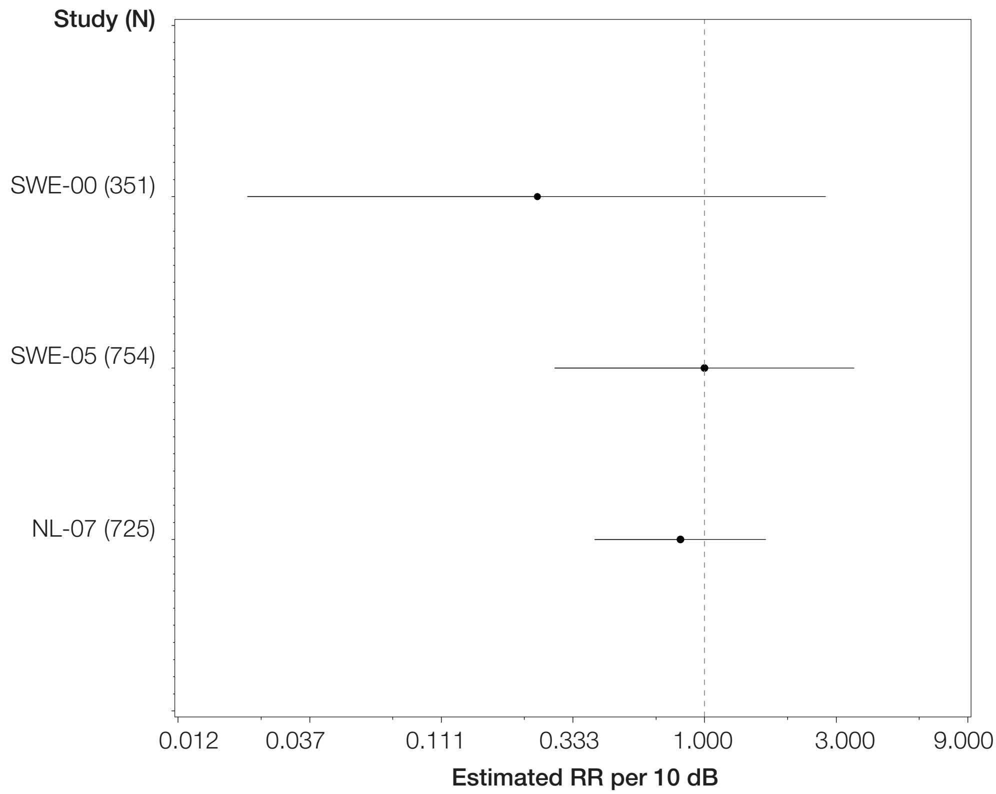
The same studies also looked at exposure to wind turbine noise and self-reported cardiovascular disease, but none found an association. No evidence was available for other measures of cardiovascular disease. As a result, only evidence rated very low quality was available for no considerable effect of audible noise (greater than 20 Hz) from wind turbines or wind farms on self-reported cardiovascular disease (see Fig. 15).

Fig. 14. The association between exposure to wind turbine noise (sound pressure level in dB) and hypertension



Notes: The dotted vertical line corresponds to no effect of exposure to wind turbine noise. The black dots correspond to the estimated RR per 10 dB and 95% CI. For further details on the studies included in the figure please refer to the systematic review on environmental noise and cardiovascular and metabolic effects (van Kempen et al., 2018).

Fig. 15. The association between exposure to wind turbine noise (sound pressure level) and self-reported cardiovascular disease



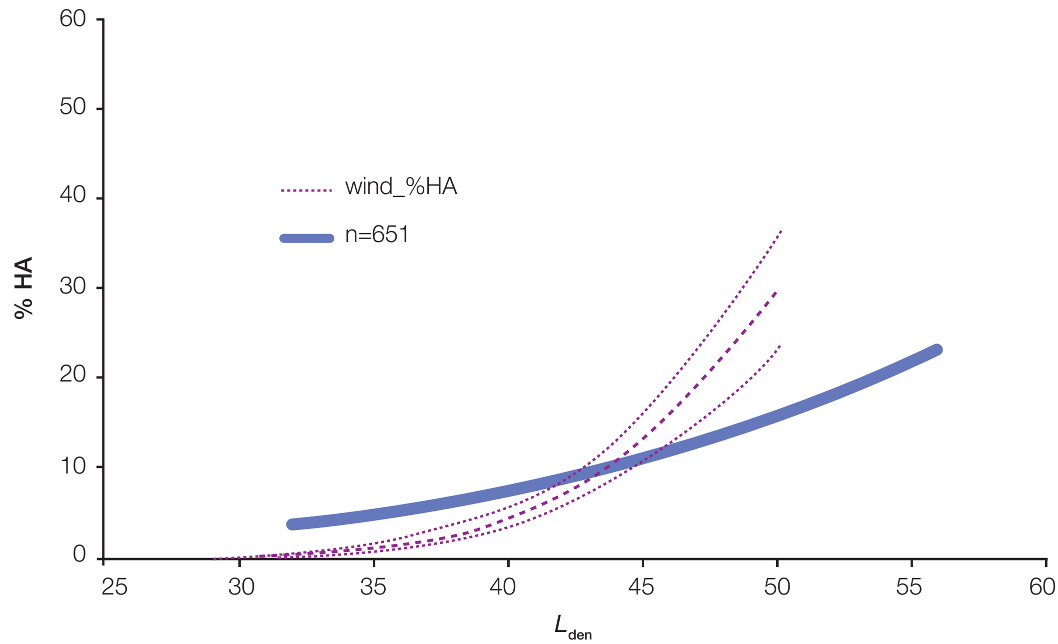
Notes: The dotted vertical line corresponds to no effect of exposure to wind turbine noise.The black circles correspond to the estimated RR per 10 dB (sound pressure level) and 95% CI. For further details on the studies included in the figure please refer to the systematic review on environmental noise and cardiovascular and metabolic effects (van Kempen et al., 2018).

Annoyance

Two publications containing descriptions of four individual studies were retrieved (Janssen et al., 2011; Kuwano et al., 2014). All four studies used measurements in the vicinity of the respondents' addresses; the noise exposure metrics used in the three original studies (Pedersen, 2011; Pedersen & Persson Waye, 2004; 2007) included in Janssen et al. (2011) were recalculated into L_{den}. The noise levels in the studies ranged from 29 dB to 56 dB. Different scales were used to assess annoyance, with slightly different definitions of "highly annoyed" and explicit reference to outdoor annoyance in the data used for the Janssen et al. (2011) curve. Construction of the ERFs provided in the two publications differed and they were therefore not further combined in a meta-analysis. Fig. 16 shows the %HA from the two publications. The 10% criterion for %HA is reached at around 45 dB L_{den} (where the two curves coincide). There was a wide variability in %HA between studies, with a range of 3–13%HA at 42.5 dB and 0–32%HA at 47.5 dB. The %HA in the sample is comparatively high, given the relatively low noise levels. There is evidence rated low quality for an association between wind turbine noise and annoyance, but this mainly applies to the association between wind turbine noise and annoyance and not to the shape of the quantitative relationship.

Further statistical analyses of annoyance yield evidence rated low quality for an association between wind turbine noise and %HA when comparing an exposure at 42.5 dB and 47.5 dB, with a mean difference in %HA of 4.5 (indoors) and 6.4 (outdoors). There is also evidence rated moderate quality for a correlation between individual noise exposure and annoyance raw scores (r = 0.28).

Fig. 16. Overlay of the two wind turbine annoyance graphs



Notes: Overlay of the two wind turbine outdoor annoyance graphs adapted from Janssen et al. (2011, red) and Kuwano et al. (2014, blue). The Kuwano et al. curve is based on L_{dn}; no correction for L_{den} has been applied.[18]
For further details on the studies included in the figure please refer to the systematic review on environmental noise and annoyance (Guski et al., 2017).

Cognitive impairment, hearing impairment and tinnitus, adverse birth outcomes

No studies were found, and therefore no evidence was available on the relationship between wind turbine noise and measures of cognitive impairment; hearing impairment and tinnitus; and adverse birth outcomes.

Sleep disturbance

Six cross-sectional studies on wind turbine noise and self-reported sleep disturbance were identified (Bakker et al., 2012; Kuwano et al., 2014; Michaud, 2015; Pawlaczyk-Luszczynska et al., 2014; Pedersen & Persson Waye, 2004; 2007). Noise levels were calculated using different methods, and different noise metrics were reported. Three of the studies asked how noise affects sleep; the other three evaluated the effect of wind turbine noise on sleep using questions that explicitly referred to noise (Table 40).

[18] L_{dn} is the day-night-weighted sound pressure level as defined in section 3.6.4 of ISO 1996-1:2016.

Table 40. Summary of findings for health effects from exposure to wind turbine noise (L_{night})

Noise metric	Priority health outcome measure	Quantitative risk for adverse health	Lowest level of effects in studies	Number of participants (studies)	Quality of evidence
Effects on sleep					
L_{night}	%HSD	1.60 (95% CI: 0.86–2.94) per 10 dB increase	31 dB	3971 (6)	Low (downgraded for study limitations, inconsistency, precision)

The risk of bias was assessed as high for all six studies, as effects on sleep were measured by self-reported data. There were a limited number of subjects at higher exposure levels. A meta-analysis was conducted for five of the six studies, based on the OR for high sleep disturbance for a 10 dB increase in outdoor predicted sound pressure level. The pooled OR was 1.60 (95% CI: 0.86–2.94). The evidence was rated low quality.

3.4.2.2 Evidence on interventions

This section summarizes the evidence underlying the recommendation on the effectiveness of interventions for wind turbine noise exposure. The key question posed was: in the general population exposed to wind turbine noise, are interventions effective in reducing exposure to and/or health outcomes from wind turbine noise? A summary of the PICOS/PECCOS scheme applied is set out in Table 41.

Table 41. PICOS/PECCOS scheme of the effectiveness of interventions for exposure to wind turbine noise

PICO	Description	
Population	**General population**	
Intervention(s)	The interventions can be defined as: (a) a measure that aims to change noise exposure and associated health effects; (b) a measure that aims to change noise exposure, with no particular evaluation of the impact on health; or (c) a measure designed to reduce health effects, but that may not include a reduction in noise exposure.	
Comparison	**No intervention**	
Outcome(s)	For average noise exposure: 1. cardiovascular disease 2. annoyance 3. cognitive impairment 4. hearing impairment and tinnitus 5. adverse birth outcomes 6. quality of life, well-being and mental health 7. metabolic outcomes	For night noise exposure: 1. effects on sleep

No studies were found, and therefore no evidence was available on the effectiveness of interventions to reduce noise exposure from wind turbines.

3.4.2.3 Consideration of additional contextual factors

As the foregoing overview has shown, very little evidence is available about the adverse health effects of continuous exposure to wind turbine noise. Based on the quality of evidence available, the GDG set the strength of the recommendation on wind turbine noise to conditional. As a second step, it qualitatively assessed contextual factors to explore whether other considerations could have a relevant impact on the recommendation strength. These considerations mainly concerned the balance of harms and benefits, values and preferences, and resource use and implementation.

Regarding the balance of harms and benefits, the GDG would expect a general health benefit from a marked reduction in any kind of long-term environmental noise exposure. Health effects of individuals living in the vicinity of wind turbines can theoretically be related not only to long-term noise exposure from the wind turbines but also to disruption caused during the construction phase. The GDG pointed out, however, that evidence on health effects from wind turbine noise (apart from annoyance) is either absent or rated low/very low quality (McCunney et al., 2014). Moreover, effects related to attitudes towards wind turbines are hard to discern from those related to noise and may be partly responsible for the associations (Knopper & Ollson, 2011). Furthermore, the number of people exposed is far lower than for many other sources of noise (such as road traffic). Therefore, the GDG estimated the burden on health from exposure to wind turbine noise at the population level to be low, concluding that any benefit from specifically reducing population exposure to wind turbine noise in all situations remains unclear. Nevertheless, proper public involvement, communication and consultation of affected citizens living in the vicinity of wind turbines during the planning stage of future installations is expected to be beneficial as part of health and environmental impact assessments. In relation to possible harms associated with the implementation of the recommendation, the GDG underlined the importance of wind energy for the development of renewable energy policies.

The GDG noticed that the values and preferences of the population towards reducing long-term noise exposure to wind turbine noise vary. Whereas the general population tends to value wind energy as an alternative, environmentally sustainable and low-carbon energy source, people living in the vicinity of wind turbines may evaluate them negatively. Wind turbines are not a recent phenomenon, but their quantity, size and type have increased significantly over recent years. As they are often built in the middle of otherwise quiet and natural areas, they can adversely affect the integrity of a site. Furthermore, residents living in these areas may have greater expectations of the quietness of their surroundings and therefore be more aware of noise disturbance. Negative attitudes especially occur in individuals who can see wind turbines from their houses but do not gain economically from the installations (Kuwano et al., 2014; Pedersen & Persson Waye, 2007; van den Berg et al., 2008). These situational variables and the values and preferences of the population may differ between wind turbines and other noise sources, as well as between wind turbine installations, which makes assessment of the relationship between wind turbine noise exposure and health outcomes particularly challenging.

Assessing resource use and implementation considerations, the GDG noted that reduction of noise exposure from environmental sources is generally possible through simple measures like insulating windows or building barriers. With wind turbines, however, noise reduction interventions are more complicated than for other noise sources due to the height of the source and because outdoor disturbance is a particularly large factor. As generally fewer people are affected (compared to transportation noise), the expected costs are lower than for other environmental sources of noise. The GDG was not aware of any existing interventions (and associated costs) to reduce harms from wind turbine noise, or specific consequences of having regulations on wind turbine noise. Therefore, it could not assess feasibility, or discern whether any beneficial effects of noise reduction would outweigh the costs of intervention. In particular, there is no clear evidence on an acceptable and uniform distance between wind turbines and residential areas, as the sound propagation depends on many aspects of the wind turbine construction and installation.

In light of the assessment of the contextual factors in addition to the quality of evidence, the recommendation for wind turbine noise exposure remains conditional.

Additional considerations or uncertainties

Assessment of population exposure to noise from a particular source is essential for setting health-based guideline values. Wind turbine noise is characterized by a variety of potential moderators, which can be challenging to assess and have not necessarily been addressed in detail in health studies. As a result, there are serious issues with noise exposure assessment related to wind turbines.

Noise levels from outdoor sources are generally lower indoors because of noise attenuation from the building structure, closing of windows and similar. Nevertheless, noise exposure is generally estimated outside, at the most exposed façade. As levels of wind turbine noise are generally much lower than those of transportation noise, the audibility of wind turbines in bedrooms, particularly when windows are closed, is unknown.

In many instances, the distance from a wind farm has been used as a proxy to determine audible noise exposure. However, in addition to the distance, other variables – such as type, size and number of wind turbines, wind direction and speed, location of the residence up- or downwind from wind farms and so on – can contribute to the resulting noise level assessed at a residence. Thus, using distance to a wind farm as a proxy for noise from wind turbines in health studies is associated with high uncertainty.

Wind turbines can generate infrasound or lower frequencies of sound than traffic sources. However, few studies relating exposure to such noise from wind turbines to health effects are available. It is also unknown whether lower frequencies of sound generated outdoors are audible indoors, particularly when windows are closed.

The noise emitted from wind turbines has other characteristics, including the repetitive nature of the sound of the rotating blades and atmospheric influence leading to a variability of amplitude modulation, which can be a source of above average annoyance (Schäffer et al., 2016). This differentiates it from noise from other sources and has not always been properly characterized. Standard methods of measuring sound, most commonly including A-weighting, may not capture the low-frequency sound and amplitude modulation characteristic of wind turbine noise (Council of Canadian Academies, 2015).

Even though correlations between noise indicators tend to be high (especially between L_{Aeq}-like indicators) and conversions between indicators do not normally influence the correlations between the noise indicator and a particular health effect, important assumptions remain when exposure to wind turbine noise in L_{den} is converted from original sound pressure level values. The conversion requires, as variable, the statistical distribution of annual wind speed at a particular height, which depends on the type of wind turbine and meteorological conditions at a particular geographical location. Such input variables may not be directly applicable for use in other sites. They are sometimes used without specific validation for a particular area, however, because of practical limitations or lack of data and resources. This can lead to increased uncertainty in the assessment of the relationship between wind turbine noise exposure and health outcomes.

Based on all these factors, it may be concluded that the acoustical description of wind turbine noise by means of L_{den} or L_{night} may be a poor characterization of wind turbine noise and may limit the ability to observe associations between wind turbine noise and health outcomes.

3.4.3 Summary of the assessment of the strength of recommendations

Table 42 provides a comprehensive summary of the different dimensions for the assessment of the strength of the wind turbine recommendations.

Table 42. Summary of the assessment of the strength of the recommendation

Factors influencing the strength of recommendation	Decision
Quality of evidence	**Average exposure (L_{den})** *Health effects* • Evidence for a relevant absolute risk of annoyance at **45 dB L_{den}** was rated **low quality.** *Interventions* • No evidence was available on the effectiveness of interventions to reduce noise exposure and/or health outcomes from wind turbines. **Night-time exposure (L_{night})** *Health effects* • No statistically significant evidence was available for sleep disturbance related to exposure from wind turbine noise at night. *Interventions* • No evidence was available on the effectiveness of interventions to reduce noise exposure and/or sleep disturbance from wind turbines.
Balance of benefits versus harms and burdens	Further work is required to assess fully the benefits and harms of exposure to environmental noise from wind turbines and to clarify whether the potential benefits associated with reducing exposure to environmental noise for individuals living in the vicinity of wind turbines outweigh the impact on the development of renewable energy policies in the WHO European Region.
Values and preferences	There is wide variability in the values and preferences of the population, with particularly strong negative attitudes in populations living in the vicinity of wind turbines.
Resource implications	Information on existing interventions (and associated costs) to reduce harms from wind turbine noise is not available.
Additional considerations or uncertainties	There are serious issues with noise exposure assessment related to wind turbines.
Decisions on recommendation strength	• **Conditional** for guideline value for average noise exposure (L_{den}) • **Conditional** for the effectiveness of interventions (L_{night})

3.5 Leisure noise

Recommendations

For average noise exposure, the GDG **conditionally** recommends reducing the yearly average from all leisure noise sources combined to **70 dB** $L_{Aeq,24h}$, as leisure noise above this level is associated with adverse health effects. The equal energy principle[19] can be used to derive exposure limits for other time averages, which might be more practical in regulatory processes.

For single-event and impulse noise exposures, the GDG **conditionally** recommends following existing guidelines and legal regulations to limit the risk of increases in hearing impairment from leisure noise in both children and adults.

Following a precautionary approach, to reduce possible health effects, the GDG **strongly** recommends that policy-makers take action to prevent exposure above the guideline values for average noise and single-event and impulse noise exposures. This is particularly relevant as a large number of people may be exposed to and at risk of hearing impairment through the use of personal listening devices (PLDs). There is insufficient evidence, however, to recommend one type of intervention over another.

3.5.1 Rationale for the guideline levels for leisure noise

As specific evidence for the relationship between leisure noise and hearing loss is of insufficient quality, the GDG decided to follow a different approach for this noise source, based on knowledge regarding prevention of hearing loss in the workplace and on the CNG (WHO, 1999). There is sufficient evidence that the nature of the noise matters little in causing hearing loss, so using the existing guidelines is a justified step to prevent permanent hearing loss from leisure noise.

In accordance with the procedures for the other noise sources, the GDG would have considered evidence on exposure–response relationships for the prioritized health outcomes. However, no such ERFs could be established in the systematic reviews for any of the health outcomes (Table 43).

Table 43. Average exposure levels ($L_{Aeq,24h}$) for priority health outcomes from leisure noise

Summary of priority health outcome evidence	Benchmark level	Evidence quality
Incidence of IHD **Incidence of hypertension** **Prevalence of highly annoyed population** **Reading skills and oral comprehension in children**		No evidence was available
Permanent hearing impairment There is an indication that PLDs have an effect on hearing impairment and tinnitus. There was no evidence (because no studies were found) for an effect of other sources of leisure noise on hearing impairment or tinnitus. The results of the studies could not be synthesized because of heterogeneity of outcome measurement.	No increase	Very low quality/no evidence

[19] The equal energy principle states that the total effect of sound is proportional to the total amount of sound energy received by the ear, irrespective of the distribution of that energy in time (WHO, 1999).

In accordance with the evidence on the effects of PLDs on permanent hearing loss from leisure noise, the GDG recommended a guideline exposure level of 70 dB $L_{Aeq,24h}$ yearly average from all leisure noise sources combined. It was confident that there was no relevant risk increase for permanent hearing impairment below this exposure level of average leisure noise. The GDG recognized that a conversion to alternative time averages for exposure to leisure noise might be helpful for regulatory purposes; thus, a detailed table converting hourly and weekly exposure into yearly averages is provided in the subsection on additional considerations or uncertainties in section 3.5.2.3, Table 49. Furthermore, the GDG recommended sticking to the CNG recommendations for single events to limit the risk of hearing impairment from leisure noise increases for both children and adults (WHO, 1999).[20] Due to the nature and limited amount of available evidence, the GDG made the recommendation conditional.

Next, the GDG assessed the evidence for night noise exposure and its effect on sleep disturbance (Table 44).

Table 44. Night-time exposure levels (L_{night}) for priority health outcomes from leisure noise

Summary of priority health outcome evidence	Benchmark level	Evidence quality
Sleep disturbance	3% absolute risk	No evidence was available

Because of a lack of evidence, the GDG was not able to formulate a recommendation addressing sleep disturbance due to leisure noise at night time.

The GDG also looked for evidence about the effectiveness of interventions for leisure noise exposure. Owing to a lack of research, however, no studies were available on existing interventions and associated costs to reduce leisure noise. As no evidence was available, it was not possible to develop a recommendation on any specific type of intervention measure. However, following a precautionary approach, to reduce possible health effects, the GDG made a strong recommendation that policy-makers take action to prevent exposures above the guideline values for average noise and single-event and impulse noise exposures. This is particularly relevant as a large number of people may be exposed to and at risk of hearing impairment through the use of PLDs. There is insufficient evidence, however, to recommend one type of intervention over another.

3.5. 1.1 Other factors influencing the strength of recommendations

Other factors considered in the context of recommendations on leisure noise included those related to values and preferences, benefits and harms, resource implications, equity, acceptability and feasibility; moreover, nonpriority health outcomes were considered. Ultimately, the assessment of all these factors did not lead to a change in the strength of recommendation. Further details are provided in section 3.5.2.3.

[20] The GDG acknowledged the scarcity of cohort study-based evidence to define a threshold for hearing damage due to single loud exposures. It initially decided to propose $L_{AF,max}$ = 110, but after much discussion it appeared that the conversion of relevant standing limits (expressed in $L_{peak,C}$ and others) lacked sufficient basis.

3.5.2 Detailed overview of the evidence

The following sections provide a detailed overview of the evidence constituting the basis for setting the recommendations on leisure noise. As noted above, however, only limited evidence was available for several of the prioritized health outcomes, so it is presented and summarized for all critical and important health outcomes where possible, along with indications of the GDG's judgement of the quality of evidence. Research into health outcomes and effectiveness of interventions is addressed consecutively.

A comprehensive summary of all evidence considered for each of the critical and important health outcomes can be found in the eight systematic reviews published in the *International Journal of Environmental Research and Public Health* (see section 2.3.2 and Annex 2).

3.5.2.1 Evidence on health outcomes

The key question posed was: in the general population exposed to leisure noise, what is the exposure–response relationship between exposure to leisure noise (reported as various noise indicators) and the proportion of people with a validated measure of health outcome, when adjusted for main confounders? A summary of the PICOS/PECCOS scheme applied and the main findings is set out in Tables 45 and 46.

Table 45. PICOS/PECCOS scheme of critical health outcomes for exposure to leisure noise

PECO	Description	
Population	General population	
Exposure	Exposure to high levels of noise produced by leisure activities (average/night time)	
Comparison	Exposure to lower levels of noise produced by leisure activities (average/night time)	
Outcome(s)	For average noise exposure: 1. cardiovascular disease 2. annoyance 3. cognitive impairment 4. hearing impairment and tinnitus 5. adverse birth outcomes 6. quality of life, well-being and mental health 7. metabolic outcomes	For night noise exposure: 1. effects on sleep

Table 46. Summary of findings for health effects from exposure to leisure noise ($L_{Aeq,24h}$)

Noise metric	Priority health outcome measure	Quantitative risk for adverse health	Lowest level of exposure across studies[a]	Number of participants (studies)	Quality of evidence
Cardiovascular disease					
$L_{Aeq,24}$	Incidence of IHD	–	–	–	–
$L_{Aeq,24}$	Incidence of hypertension	–	–	–	–
Annoyance					
$L_{Aeq,24}$	%HA	–	–	–	–
Cognitive impairment					
$L_{Aeq,24}$	Reading and oral comprehension	–	–	–	–
Hearing impairment and tinnitus					
$L_{Aeq,24}$	Permanent hearing impairment	Not estimated	–	484 (3)	Very low (downgraded for study limitations, precision)

Hearing impairment and tinnitus

Several types of leisure activity are accompanied by loud sounds, such as attending nightclubs, pubs and fitness classes; live sporting events; concerts or live music venues; listening to loud music through PLDs. This recommendation is informed by a systematic review that assessed the evidence on permanent hearing loss and tinnitus due to exposure to leisure noise (Śliwińska-Kowalska & Zaborowski, 2017). The review identified two existing systematic reviews that summarized recent estimates of the risk of developing permanent hearing loss from the use of PLDs. It did not identify any studies with objective measurement of exposure to any other type of leisure noise.

The Scientific Committee on Emerging and Newly Identified Hazards and Risk (SCENIHR) (EC, 2008b) report concluded that prolonged exposure to sounds from PLDs may result in temporary hearing threshold shift, permanent hearing threshold shift and tinnitus, as well as poor speech communication in noisy conditions. However, based on the data available, there was no direct evidence for an effect of repeated, regular daily exposure to music through PLDs on development of permanent noise-induced hearing loss. Data on tinnitus were inadequate and therefore inconclusive. No meta-analysis was provided for any of the hearing effects; nor were the exposure–effect curves reported. The SCENIHR report was based on a narrative review of 30 original papers with over 2000 participants and exposure to music sounds that covered a range of 60–120 dB. Studies included in the review were carried out between 1982 and 2007.

In 2014 a second systematic review was published by Vasconcellos et al. (2014). Although the objective of this publication was to determine threshold levels of personally modifiable risk factors for hearing loss in the paediatric population, specific thresholds analyses were limited. Based on the descriptive overview of original papers, the authors identified exposure to loud music (including use of PLDs) and working on a mechanized farm as the main risk factors for hearing loss in children and teenagers. Thresholds of exposure to music, significantly associated with hearing loss in youth, were:

- more than four hours per week or more than five years of personal headphone usage;
- more than four visits per month to a discotheque.

The evidence review identified five new cross-sectional studies on noise from PLDs since the publication of the SCENIHR report (Feder et al., 2013; Levesque et al., 2010; Sulaiman et al., 2013; 2014; Vogel et al., 2014). Direct measurement of hearing thresholds with pure tone audiometry was performed only in three studies – by Feder et al. (2013) and Sulaiman et al. (2013 and 2014). In total, audiometric data from 484 subjects were analysed; among them, 449 were exposed and 35 were not exposed to PLD music. Two other studies by Levesque et al. (2010) and Vogel et al. (2014) did not perform audiometric measurement but reported on tinnitus in a total of 1067 participants.

Noise from PLDs was estimated based on direct measurement of equivalent sound pressure levels (in dB) in four studies (Feder, 2013; Levesque et al., 2010; Sulaiman et al., 2013; 2014) and based on converting volume-control setting levels of PLD into dB levels in one study (Vogel et al., 2014). The resulting exposure levels (L_{Aeq} values) had a mean of between 72 dB and 91 dB, although in two studies these data were not provided. In all studies, individual $L_{Aeq,8h}$ value was calculated based on an estimated level of music and the number of hours a day listening to the music through the PLD declared by an individual in the questionnaire. Resulting $L_{Aeq,8h}$ mean values were between 62 dB and 83 dB when provided.

Potential confounding was controlled by excluding the subjects with exposure to other sources of high-level noise or prior ear problems (Sulaiman et al., 2013), by excluding those with these factors and ototoxic drug intake (Sulaiman et al., 2014) or by controlling for these confounders by accounting for them in the statistical models. The confounders comprised socioeconomic status, demographic factors, tubes in the ear and leisure exposures in one study (Feder, 2013), and age and sex in one study (Vogel et al., 2014). One of the studies did not adjust for confounding factors (Levesque et al., 2010).

Data on permanent hearing loss were taken from audiometric measurements (Feder, 2013; Sulaiman et al., 2013; 2014), while data about permanent tinnitus were taken from self-reported responses to questionnaires (Levesque et al., 2010; Vogel et al., 2014). In one case, the outcome was defined as “permanent hearing-related symptoms”, but it is not clear what proportion of subjects experienced permanent tinnitus (Vogel et al., 2014).

For permanent hearing loss, there is no pooled effect size, because the authors of the original studies either did not report data or reported in different formats. However, these studies indicate a harmful effect of listening to PLDs. For permanent tinnitus, there is no pooled effect size because the effects of noise from PLDs on permanent tinnitus were contradictory. These results are generally consistent with previous reviews by SCENIHR (EC, 2008b) and Vasconcellos et al. (2014).

The risk of bias was assessed as high for all five studies. The overall evidence for an effect of PLDs on hearing impairment and tinnitus was rated very low quality.

3.5.2.2 Evidence on interventions

The following section summarizes the evidence underlying the recommendation on the effectiveness of interventions for leisure noise exposure. The key question posed was: in the general population exposed to leisure noise, are interventions effective in reducing exposure to and/or health outcomes from leisure noise? A summary of the PICOS/PECCOS scheme applied and the main findings is set out in Tables 47 and 48.

Table 47. PICOS/PECCOS scheme of the effectiveness of interventions for exposure to leisure noise

PICO	Description	
Population	General population	
Intervention(s)	The interventions can be defined as: (a) a measure that aims to change noise exposure and associated health effects; (b) a measure that aims to change noise exposure, with no particular evaluation of the impact on health; or (c) a measure designed to reduce health effects, but that may not include a reduction in noise exposure.	
Comparison	No intervention	
Outcome(s)	For average noise exposure: 1. cardiovascular disease 2. annoyance 3. cognitive impairment 4. hearing impairment and tinnitus 5. adverse birth outcomes 6. quality of life, well-being and mental health 7. metabolic outcomes	For night noise exposure: 1. effects on sleep

Table 48. Summary of findings for interventions for leisure noise

Type of intervention	Number of participants (studies)	Effect of intervention	Quality of evidence
Hearing impairment			
Type E – behaviour change interventions (education programme/campaign)	4151 (7)	None of the studies involved measurement or estimation of exposure levels or health outcomes. Most studies found a significant effect of change in knowledge or behaviour.	–

Seven individual studies on PLDs, attendance at music venues and participation in other recreational activities where there was risk of hearing damage and/or tinnitus were included in the systematic review (Dell & Holmes, 2012; Gilles & Van de Heyning, 2014; Kotowski et al., 2011; Martin et al., 2013; Taljaard et al., 2013; Weichbold & Zorowka, 2003; 2007). All studies examined interventions directed at changes in knowledge or behaviour and hearing impairment.

The studies all sought evidence on the effectiveness of some form of educational programme or campaign aimed at children, adolescents or college students. These addressed perceptions and knowledge of the risk of high levels of noise – generally, but not exclusively, from PLD sources or from attendance at music events – and actual or intended changes to hearing damage risk behaviours, including avoidance, frequency or duration of exposure, regeneration periods when in high noise, or playback levels.

The outcome assessed in all intervention studies was the change in knowledge and behaviours towards hearing damage risk. The health outcome measures varied widely and included measurements on the youth attitude towards noise scale, participants' knowledge about hearing damage, participants' PLD usage patterns, participants' attitudes to wearing hearing protection (some in general; some at discotheques) and frequency of discotheque attendance. A majority of the studies found a significant effect of change in knowledge or behaviour. No indication on the persistence of knowledge and behavioural change was given, though.

None of the studies included objectively measured outcomes or a measured change in noise level exposure; thus, the effectiveness of the interventions could not be assessed, and the quality of the evidence was not rated according to GRADE.

3.5.2.3 Consideration of additional contextual factors

Based on the quality of the available evidence discussed in the foregoing overview, the GDG set the strength of recommendation of leisure noise to conditional. As a second step, it qualitatively assessed contextual factors to explore whether other considerations could have a relevant impact on the recommendation strength. These considerations mainly concerned the balance of harms and benefits, values and preferences, and resource use and implementation.

When assessing the balance of benefits and harms, the GDG recognized that exposure to leisure noise is widespread and frequent. In particular, as many as 88–90% of teenagers and young adults report listening to music through PLDs earphones (Pellegrino et al., 2013; Vogel et al., 2011). In 2015 WHO estimated that 1.1 billion young people worldwide could be at risk of hearing loss due to unsafe listening practices (WHO, 2015a). Furthermore, among young people aged 12–35 years in middle- and high-income countries, nearly 50% listen to unsafe levels of sound through personal audio devices (mp3 players, smartphones and others), and around 40% are exposed to potentially damaging levels of sound at nightclubs, bars and sporting events. Noise-induced hearing loss can be prevented by following safe listening practices, so the GDG concluded that health benefits can be gained from markedly reducing population exposure to leisure noise, including through actions to promote safe listening practices. A reduction of leisure noise is also assumed to reduce nuisance that can be caused to other people than those who enjoy leisure activities, such as neighbours. Furthermore, specifically for PLDs, it can reasonably be expected that a reduction of noise exposure could also lead to a reduction in accidents, injuries and other potential safety risks. In relation to possible harms and burdens, the GDG could not identify any harms (except economic costs, which are addressed in the paragraph on resource use and implementation) arising from implementation of the recommended guideline values.

Considering values and preferences, the GDG recognized that listening to music with the help of a PLD, going to concerts and attending sport events are activities regarded as enjoyable and therefore assumed to be valued by the overall population. Furthermore, it is expected that values and preferences might vary in particular with respect to the use of PLDs and embracing leisure activities involving loud noise, like concerts, and that some population groups – especially younger individuals – might voluntarily expose themselves to high levels of sound during these activities. Despite this, the GDG was confident that recommendations to lower noise levels for the prevention of hearing damage from leisure noise would be welcome by a majority of the population. Recommendations are expected to be particularly welcome when it comes to protecting the hearing of young children and teenagers, as these vulnerable groups often do not have control over their environment and the noise levels to which they are exposed, such as from noisy toys or at school.

With resource use and implementation, the GDG noted that interventions exist to reduce exposure to leisure noise from PLDs, attendance at music venues and participation in recreational activities, as aggregated by the systematic review on environmental noise interventions and their associated impacts (Brown & van Kamp, 2017). As most of these relate to implementation of a behaviour change, the reduction of exposure to leisure noise is expected to be technically feasible and cheap. None of the empirical investigations objectively measured outcomes or a measured change in noise level exposure, so the effectiveness of such measures cannot be assessed. Nevertheless, it is important to note that there is ample evidence from the occupational health field that high noise levels cause hearing damage, and that occupational interventions to reduce noise exposure are effective at lowering the risk of hearing problems or hearing damage (EC, 2003; Garcia et al., 2018; ISO, 2013; Maassen et al., 2001). In conclusion, resources needed to reduce exposure to leisure noise are not expected to be intensive, but implementation and long-term success of measures might be challenging, owing to cultural factors, as changes in behaviour are expected to be tricky to implement.

In light of the assessment of the contextual factors in addition to the quality of evidence, the recommendation remains conditional.

Additional considerations or uncertainties

The GDG considers the noise levels selected for this recommendation to be reasonable precautionary measures, in view of the rating of very low quality for the available evidence on an effect of leisure noise on permanent hearing impairment and tinnitus identified in the systematic review.

Extensive literature shows hearing impairment in populations exposed to specific types of nonoccupational environments, although these exposures are generally not well characterized. There are no studies with objective measurement of exposure to any other type of leisure noise (except PLDs) and permanent hearing impairment or tinnitus. Nevertheless, this recommendation generally applies to all leisure noise exposures, such as events in public venues (concerts halls, sports events, bars and discotheques) and educational facilities, and use of PLDs. The recommendation also applies to exposure to impulse sounds, such as those in shooting facilities or from the use of toys and firecrackers.

Hearing loss is the resultant value of combined exposures to different sources of leisure noise including, but not limited to, PLDs. Therefore, the recommendations apply to the combined noise levels from all sources.

Noise-induced hearing loss develops very slowly over years of exposure, giving rise to challenges in the assessment of the health impacts from prolonged use of PLDs and exposure to leisure noise. The induction period for the development of hearing impairment and tinnitus is long, and varying exposure conditions and changing lifestyle habits (including confounding noise sources), particularly among young people, will have an impact. Therefore, recommendations regarding leisure noise have often been inferred from the occupational field, where exposure conditions are more stable over time.

Indeed, long-term exposure to noise, objectively assessed and at levels measured in occupational settings for various professions, can lead to permanent hearing loss and tinnitus. This evidence, while not reviewed systematically as part of the work related to these guidelines, can be used as supportive evidence and justification for the need to develop a recommendation for leisure noise, given that many people could be at risk of developing hearing loss and/or tinnitus from exposure to lower levels of environmental noise. Similar otobiological mechanisms must also be considered for environmental noise.

To date, no commonly accepted method for assessing the risk of hearing loss due to environmental exposure to noise has been developed. One of the main challenges is to conduct a long-term objective exposure assessment of environmental noise and relate this to the development of permanent hearing impairment and tinnitus. The GDG underlined the strong need for research to develop a comprehensive methodology. In the absence of a method, and as long as no other tools are available, the equal energy principle outlined in the ISO standard for the estimation of noise-induced hearing loss (WHO, 1999) can be used as a practical tool for protecting public health from exposure to leisure noise. As a result, the relationship between leisure noise exposure and auditory effects can be quantified for a variety of exposure levels, duration and frequency.

Several organizations have established regulations for the protection of workers from risks to their health and safety arising from exposure to noise, and in particular risk to hearing. Of particular relevance is EU Directive 2003/10/EC on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise) (EC, 2003). Based on the ISO 1999 standard (ISO, 2013), the Directive sets limits of exposure depending on equivalent noise level for an eight-hour working day and obliges the employer to take suitable steps if the limits are exceeded. It recommends three action levels for occupational settings, setting the lowest, most conservative value at $L_{ex,8hr}$ = 80 dB. According to the Directive, no consequences of exposure to occupational noise are expected at this level. While exposure patterns and certain characteristics of occupational and leisure noise exist, knowledge of the hearing impairment risks and preventive interventions can be used to assess health risks associated with leisure noise (Neitzel & Fligor, 2017).

The CNG recommend a limit of $L_{Aeq,24h}$ = 70 dB(A) for preventing hearing loss from industrial, commercial shopping and traffic areas, indoors and outdoors (WHO, 1999). Health and safety regulations are usually based on an exposure profile of a typical worker (eight hours per day, five days per week). Using the existing knowledge from the ISO standard and established health and safety regulations, it is possible to use the equal energy principle to derive the resulting noise exposure level for an exposure profile more appropriately suited for leisure noise. Converting 40 hours at 80 dB to a continuous exposure to noise (24 hours per day, seven days per week), this leads to a yearly average exposure of 71 dB for lifelong exposure.[21] This is the same value as the WHO recommendation of

[21] 71 dB = 80 dB (derived from ISO standard) – 6.2 dB (conversion of yearly average of 40 working hours divided by continuous exposure to noise: (10 log (2080hrs/8760 hrs)) – 3 dB (extrapolation of 40 working years to lifelong exposure).

70 dB (WHO, 1999). Table 49 presents the noise levels per hour for various time averages in order to keep within the recommended yearly average exposure, and assuming that exposure to other noise sources generally does not contribute significantly. For example, for specific events taking place for one-, two- or four-hour averages, once a week (such as visiting a discotheque or watching a loud movie), an hourly noise level of 85 dB would lead to an average yearly exposure of 63 dB, 66 dB and 69 dB, respectively. However, the same hourly exposure of 85 dB for an activity taking place for 14 hours per week (two hours per day, seven days a week) would lead to a yearly exposure of 74 dB, which exceeds the recommendations.

Table 49. Combination of hourly exposure and number of hours per week to arrive at a yearly average L_{Aeq}

Hours of exposure per week	One-hour exposure level (L_{Aeq})						
	70	**75**	**80**	**85**	**90**	**95**	**100**
1	48	53	58	63	68	73	78
2	51	56	61	66	71	76	81
4	54	59	64	69	74	79	84
14 (2 hours per day, 7 days per week)	59	64	69	74	79	84	89
28 (4 hours per day, 7 days per week)	62	67	72	77	82	87	92
40 (8 hours per day, 5 days per week)	64	69	74	79	84	89	94
168 (24 hours per day, 7 days per week)	70	75	80	85	90	95	100

Note: green = combinations of exposure/duration below current guideline level; red = combinations of exposure/duration above current guideline level; blue = input parameters.

The equal energy principle cannot be used to derive single-event limits because at high levels the ear starts to respond with nonlinear behaviour. The CNG provides several values, in different units: $L_{AF,max}$ = 110 dB for industrial noises (no distance stated), $L_{peak,lin}$ = 140 dB for adults and $L_{peak,lin}$ = 120 dB for children (measured at 100 mm) (WHO, 1999). EU Directive 2003/10/EC on the minimum health and safety requirements regarding the exposure of workers recommends a lower action level of $L_{peak,C}$ = 135 dB (at 100 mm). In a recent overview Hohmann (2015) provided an ERF for hearing damage caused by shooting noise, from which it appears that a safe level of L_E = 120 dB can be derived.

Although it is clear that high noise levels cause acute hearing damage, there is no agreement on a safe level. Further research is highly recommended. In the mean time, existing guidelines should be applied.

3.5.3 Summary of the assessment of the strength of recommendation

Table 50 provides a comprehensive summary of the different dimensions for the assessment of the strength of the leisure noise recommendations.

Table 50. Summary of the assessment of the strength of the recommendation

Factors influencing the strength of recommendation	Decision
Quality of evidence	**Average exposure ($L_{Aeq,24h}$)** *Health effects* • Evidence of an effect from PLDs on hearing impairment and tinnitus, in the absence of evidence for other health outcomes and absence of evidence on hearing impairment and tinnitus from other types of leisure noise besides PLDs, was rated **very low quality.** *Interventions* • No evidence was available on the effectiveness of interventions to reduce noise exposure and/or health outcomes from leisure noise.
Balance of benefits versus harms and burdens	The general benefit from reduction of leisure noise outweighs any potential harms.
Values and preferences	There is variability in the values and preferences of the general population.
Resource implications	The resources needed to reduce exposure to leisure noise are not expected to be intensive, but implementation and the long-term success of measures may be challenging, mainly due to cultural factors.
Decision on strength of recommendation	• **Conditional** for guideline level for average noise exposure ($L_{Aeq,24h}$) • **Conditional** for single-event and impulse noise • **Strong** for interventions to reduce noise exposure

3.6 Interim targets

An interim target was proposed in the NNG (WHO Regional Office for Europe, 2009), "recommended in situations where the achievement of NNG is not feasible in the short run for various reasons". The NNG emphasized that an interim target is "not a health-based limit value by itself. Vulnerable groups cannot be protected at this level".

The GDG discussed whether to propose interim targets as part of the current guidelines, and if so, what process would be needed to derive those values. The current recommendations are health-based and already provide guideline values per noise source (for both L_{den} and L_{night}). They also include information on exposure–response relationships for various health outcomes, which can be used by policy-makers or other stakeholders to inform the selection of different values, if needed. Further, interim targets may work differently in different countries and for different noise sources, and it may not be optimal to propose them Europe-wide. As a result, there was consensus among members of the GDG not to provide interim targets.

4. Implications for research

The development of these environmental noise guidelines for the WHO European Region has made evident some key knowledge gaps and research needs. The main ones specific to the guideline recommendations are presented as implications for research in the sections that follow.

4.1 Implications for research on health impacts from transportation noise

For the assessment of health effects from the main sources of transportation noise (road traffic, railways and aircraft), the various evidence reviews show the following knowledge gap: there is a need for longitudinal studies on the health impacts from exposure to environmental noise, to inform future recommendations properly (Table 51).

Table 51. Implications for research on health impacts from transportation noise (air, rail, road)

Current state of the evidence	Limited evidence is available on health impacts from transportation noise from large-scale cohort and case-control studies, with objective measurement of both noise exposure and health outcomes.
Population of interest	Research is needed into effects of exposure on children and adults exposed to environmental noise from transportation sources.
Exposure of interest	Objective measurement or calculation of transportation noise exposure is required; in particular, from studies of health effects related to combined exposure to different noise sources.
Comparison of interest	The data should be compared to the effects of lower levels of transportation noise.
Outcomes of interest	Measures of the following health outcomes is required, assessed objectively and harmonized where possible – for example, according to common protocols: • annoyance • effects on sleep • cardiovascular and metabolic effects • adverse birth outcomes • cognitive impairment • mental health, quality of life and well-being • hearing impairment and tinnitus • any other relevant health outcome.
Time stamp	The systematic review included studies between October 2014 and December 2016.

4.1.1 Specific implications for annoyance

To predict absolute %HA at the full range of levels (and the corresponding CIs), an integrated analysis of the original raw data from all of individual studies would be necessary. The evidence review conducted as part of the guidelines focused only on secondary data handling and therefore does not replace a full meta-analysis of all individual data. The development of a generic exposure–response relationship (from a full meta-analysis based on all individual data) is suggested as a priority research recommendation (see Table 52).

Table 52. Recommendation for research addressing the exposure–response relationship

Current state of the evidence	The evidence review on annoyance conducted as part of the guidelines does not provide a generalized ERF but points to significant differences compared to the curves used in the past. It shows that the available generalized ERFs are in need of adjustment, preferably as a result of undertaking a full meta-analysis. This is especially the case for the sources aircraft and railway noise, which new data show are more annoying than previously documented.
Population of interest	Research is needed into effects of exposure on children and adults exposed to air, rail and/or road traffic noise.
Exposure of interest	Objective measurement of transportation noise exposure is required.
Comparison of interest	The data should be compared to the effects of lower levels of transportation noise.
Outcomes of interest	Measures of health outcomes are required, assessed objectively according to common protocols (such as the International Commission on Biological Effects of Noise (ICBEN) scale for annoyance).
Time stamp	The systematic review included studies up to October 2014.

4.2 Implications for research on health impacts from wind turbine noise

Further research into the health impacts from wind turbine noise is needed so that better-quality evidence can inform any future public health recommendations properly. For the assessment of health effects from wind turbines, the evidence was either unavailable or rated low/very low quality. Recommendations for research addressing this priority are proposed in Table 53.

Table 53. Implications for research on health impacts from wind turbine noise

Current state of the evidence	The current evidence on health outcomes related to wind turbine noise is unavailable or of low/very low quality and mainly comes from cross-sectional studies. Methodologically robust longitudinal studies with large samples investigating the quantitative relationship between noise from wind turbines and health effects are needed.
Population of interest	Research is needed into effects of exposure on children and adults exposed and living near sources of wind turbine noise. Studies should assess subgroup differences in effects for vulnerable groups such as children, elderly people and those with existing poor physical and mental health.
Exposure of interest	Exposure to noise at a wide range of levels and frequencies (including low-frequency noise), with information on noise levels measured outdoors and indoors (particularly relevant for effects on sleep) at the residence is needed. The noise exposure should be measured objectively and common protocols for exposure to wind turbine noise should be established, considering a variety of noise characteristics specific to wind turbine noise.
Comparison of interest	The data should be compared to the effects in similar areas without wind turbines. Pre/post studies of new wind turbine installations are needed, especially if “before measures” unbiased by the stress and knowledge of potential wind turbine farm development need to be developed.
Outcomes of interest	Measures of health outcomes are required, assessed objectively – for example, according to common protocols (ICBEN scale for annoyance and self-reported sleep disturbance). The studies should include the most important situational and personal confounding variables, such as negative attitudes towards wind turbines, visual impact, economic gain and other socioeconomic factors.
Time stamp	The systematic review included studies between October 2014 (review on annoyance) and December 2016 (review on cardiovascular disease).

Alongside the defined needs for research on wind turbine noise it should be noted that research regarding industrial noise in general is required. More specifically, there is a need to investigate stationary sources (including heat, ventilation and acclimatization devices) and their impacts on health. Studies on hearing disorders from impulse and/or intermittent sounds are also needed; these would enable assessment of adverse effects created by one or several sounds of short duration with a high maximum sound level or impulse sound level.

4.3 Implications for research on health impacts from leisure noise

For the assessment of effects from leisure noise, the evidence to make a recommendation on the ERF to use for health risk assessment, or of a threshold for effects, was either unavailable or rated very low quality. This is a research gap: longitudinal studies with longer follow-up are needed; these should measure noise objectively, not only from PLDs but also from other types of leisure noise.

There is uncertainty in the measurement of early hearing disorders among young people using the tonal audiometry commonly applied. Precise methods to identify early hearing impairment and other hearing disorders are needed. Owing to long induction periods, however, adequate research may be difficult to perform, particularly among young people who change their exposure in terms of sound level and frequency as they age (for example, changing their music listening habits and venue visits). As a result, the recommendations refer to the results derived from stationary noise sources in the occupational field, in conjunction with the equal energy principle (see Table 54).

Table 54. Implications for research on health impacts from leisure noise

Current state of the evidence	Currently, no evidence is available on hearing impairment and tinnitus from large-scale cohort and case-control studies, with objective measurement of noise exposure and using a suitable method to assess hearing impairment in young people.
Population of interest	Research is needed into effects of exposure on children and adults exposed to environmental noise from different sources and in different settings.
Exposure of interest	Objective measurement of leisure noise exposure is required.
Comparison of interest	The data should be compared to the effects of no leisure noise exposure from these sources.
Outcomes of interest	The primary outcomes identified are: • hearing loss measured by audiometry; • specific threshold analyses focused on stratifying the risk of permanent hearing loss according to clearly defined levels of exposure to leisure noise, such as music through PLDs; • concise methods to identify early hearing impairment and other hearing disorders; • temporary threshold shift after exposure to leisure noise, as it may be reasonably predictive of future permanent threshold shift; • age-related hearing loss progression depending on early-age exposure to leisure noise, such as to loud music; and • tinnitus, measured objectively and subjectively.
Time stamp	The systematic review included studies up to June 2015.

4.4 Implications for research on effectiveness of interventions to reduce exposure and/or improve public health

The quality of the evidence on the effectiveness of interventions to reduce exposure to and health outcomes from environmental noise was variable. Further studies directly linking noise interventions to health outcomes are required, particularly for sources other than road traffic noise, and for human health outcomes other than annoyance.

Most studies involved road traffic noise (63%), followed by aircraft noise (13%) and railway noise (6%). The remaining interventions were for leisure noise (13%) and noise in hospital settings (4%). No interventions were identified that either addressed wind turbine noise or focused on educational settings.

Exposure-related interventions were mainly associated with a reduction in environmental noise exposure. However, in five studies (four road traffic noise studies and one aircraft noise study) some or all of the participants experienced noise exposure increases.

There is no clear evidence with respect to thresholds, which are defined as:

- the smallest change in exposure levels that results in a change in outcome; and
- the minimum before-level, regarding changes in health outcomes as a result of interventions.

The limited evidence base on the health effects of environmental noise interventions is thinly spread across different noise source types, outcomes and intervention types. Diversity exists between studies even within intervention types in terms of study designs, methods of analysis, exposure levels and changes in exposure experienced as a result of the interventions. For these reasons, carrying out a meta-analysis across studies examining the association between changes in level and changes in outcome was not possible.

To remedy this main research gap, longitudinal studies assessing noise exposure and health outcomes objectively should be developed, taking into account the most relevant confounders. The establishment of common protocols for future research is warranted (see Table 55).

Authorities should include significant funding for the design and implementation of studies to evaluate the effectiveness of interventions to reduce noise and their impact on health.

Table 55. Implications for research on effectiveness of interventions to reduce exposure and/or improve public health

Current state of the evidence	The current evidence on effectiveness of interventions to reduce health outcomes is limited and of varying quality. Few longitudinal studies have been done that take into account the most relevant confounders and measure the noise exposure and the outcomes objectively.
Population of interest	Research is needed into effects of interventions on defined populations exposed to and/or living near sources of environmental noise.
Intervention of interest	Research into any noise intervention at various points along the system pathway between source and outcome, for a variety of noise sources, is required.
Comparison of interest	The data should be compared to: • a steady-state control group, in similar areas with various exposure gradients from environmental noise sources; • the noise exposure in the same population, through a series of sequential measurements assessing the change before and after the intervention, preferably with multiple after measurements.
Outcomes of interest	Future intervention studies should use validated and, where possible, harmonized measures of exposure and outcome, as well as of moderators and confounders. The studies should use measures of exposure including noise exposure at a wide range of levels and frequencies (including low-frequency noise), with information on noise levels outdoors and indoors (particularly relevant for effects on sleep). They should also use measures of health outcomes, including the following outcomes assessed objectively – for example, according to common protocols (ICBEN scale for annoyance) – with consideration that the change in human response for some health outcomes from a step change in exposure may have a different time course to that of the change in exposure: • annoyance • effects on sleep • cardiovascular and metabolic diseases • adverse birth outcomes • cognitive impairment • mental health, quality of life and well-being • hearing impairment and tinnitus • any other relevant health outcome. Further, they should use measures of moderators and confounders, including repeated measurements of situational and personal variables such as activity interference, potential confounders such as noise sensitivity, coping strategies and a range of other attitudinal variables.
Time stamp	The systematic review included studies up to October 2014.

5. Implementation of the guidelines

5.1 Introduction

These guidelines focus on the WHO European Region and provide guidance to Member States that is compatible with the noise indicators used in the EU's END (EC, 2002a). They provide information on the exposure–response relationships between exposure to environmental noise from different noise sources and the proportion of people affected by certain health outcomes, as well as interventions that are considered efficient in reducing exposure to environmental noise and related health outcomes.

The WHO guideline values are evidence-based public health-oriented recommendations. As such, they are recommended to serve as the basis for a policy-making process in which policy options are considered. In the policy decisions on reference values, such as noise limits for a possible standard or legislation, additional considerations – such as feasibility, costs, preferences and so on – feature in and can influence the ultimate value chosen as a noise limit. WHO acknowledges that implementing the guideline recommendations will require coordinated effort from ministries, public and private sectors and nongovernmental organizations, as well as possible input from international development and finance organizations. WHO will work with Member States and support the implementation process through its regional and country offices.

5.2 Guiding principles

Four guiding principles provide generic advice and support when incorporating the recommendations into a policy framework, and apply to the implementation of all the recommendations.

The **first principle** is to reduce exposure to noise, while conserving quiet areas. The recommendations focus on reduction of population exposure to environmental noise from a variety of sources, in different settings. The general population can be exposed regularly to more than one source of noise simultaneously (including, in some cases, occupational noise), as well as to other nonacoustic factors that can modify the response to noise (such as vibration from railways, air pollution from traffic or visual aspects of wind turbines). Thus, overall reduction of exposure from all sources should be promoted. Furthermore, noise exposure reduction in one area should not come at the expense of an increase in noise elsewhere; existing large quiet outdoor areas should be preserved.

The **second principle** is to promote interventions to reduce exposure to noise and improve health. The evidence from epidemiological studies on adverse health effects at certain noise levels, used as a basis to derive the guideline values proposed in the recommendations, supports the promotion of noise interventions. The potential health impacts from environmental noise are significant, especially when considering the widespread exposure to environmental noise across the population and the high baseline rates for various health outcomes associated with environmental noise.

There are challenges in assessment of the effectiveness of interventions to reduce noise exposure and/or improve health, as there is often a significant time lag between the intervention and a measurable change in exposure and related health benefits. The lack of – or limited direct evidence for – quantifiable health benefits of some specific interventions does not imply that measures to achieve population exposure according to the proposed guidelines should be ignored.

Given the different factors that determine noise exposure, a single measure alone may not be sufficient to reduce exposure and/or improve health significantly, and a combination of methods may be warranted. Nevertheless, it is widely acknowledged that the most effective actions to reduce exposure tend to be those that reduce noise at the source. Such actions have the biggest potential, whereas other measures can be less effective or sustained over time, especially when they depend on behaviour change or noise reductions inside houses.

The **third principle** is to coordinate approaches to control noise sources and other environmental health risks. Considering the common transport-related sources of environmental noise and air pollution, and in particular the evidence of independent effects on the cardiovascular system, a coordinated approach to policy development in the sectors related to urban planning, transport, climate and energy should be adopted for policies with an impact on environmental noise, air quality and/or climate. Such an approach should yield multiple benefits through increased commitment and financial resources; increased attention to securing health considerations in all policies; and use of policy to control noise and other environmental risks such as air pollutants, including short-lived climate pollutants. There is wide consensus on the value of pursuing coordinated policies that can deliver health and other benefits, such as those associated with the local environment and economic development. Furthermore, coordinated policy-making is potentially cost-saving.

The **fourth principle** is to inform and involve communities that may be affected by a change in noise exposure. In planning new urban and/or rural developments (transport schemes, new infrastructures in less densely populated areas, noise abatement and mitigation strategies), bringing together planners, environmental professionals and public health experts with policy-makers and citizens is key to public acceptability and involvement and to the successful guidance of the decision-making proces. Potential health effects from environmental noise should be included as part of health impact assessments of future policies, plans and projects, and the communities potentially affected by a positive or negative change in noise exposure should be well informed and engaged from the outset to maximize potential benefits to health. Introducing measures incrementally may help with acceptance.

5.3 Assessment of national needs and capacity-building

National needs, including the need for capacity-building, differ between Member States in the WHO European Region. They depend on the existence and level of implementation of national and/or European and international noise policies; these are more likely to be implemented fully in EU countries thanks to the legally binding provisions of the EU's END (EC, 2002a). In most countries in the Region noise is perceived as a major and growing environmental health and public health problem. Noise mapping and action plans are carried out in accordance with the END in EU Member States, and in south-eastern European countries noise legislation has mainly been harmonized with the END. Nevertheless, significant differences still exist in the completeness and regular updating of noise exposure assessment between countries. Noise exposure assessment is a required input for noise health impact assessments, along with exposure–response relationships and population baseline data.

WHO has identified some common needs for knowledge transfer and capacity-building for health risk assessment of environment noise in the Member States that joined the EU after 2003, the newly independent states and south-eastern European countries (WHO Regional Office for Europe, 2012):

- implementation of the END and its annexes, especially in the preparation of strategic noise mapping and action plans;
- human resources development through education and training in health risk assessment and burden of diseases stemming from environmental noise;
- methodological guidance for health risk assessment of environmental noise.

These guidelines mostly recommend exposure–response relationships related to the exposure indicators L_{den} and L_{night}. They are therefore of particular relevance to EU countries and those applying the END. In countries that do not use these indicators, users of the guidelines need to convert their noise indicators into L_{den} and L_{night} before being able to apply the recommendations. Conversion between indicators is possible, using a certain set of assumptions (Brink et al., 2018).

5.4 Usefulness of guidelines for target audiences

The provision of guideline values as a practical tool for guiding exposure reduction and the design of effective measures and policies is widely seen as useful. The WHO guidelines equip policy-makers and other end-users with a range of different needs with the necessary evidence base to inform their decisions. As indicated in section 1.4, these guidelines serve as a reference for several target audiences, and for each group they can be useful in different ways.

- For technical experts and decision-makers, the guidelines can be used to provide exposure–response relationships that give insight into the consequences of certain regulations or standards on the associated health effects. They also can be useful at the national and international level when developing noise limits or standards, as they provide the scientific basis to identify the levels at which environmental noise causes a significant health impact. Based on these recommendations, national governments and international organizations can be better informed when introducing noise limits, to ensure protection of people's health.
- For health impact assessment and environmental impact assessment practitioners and researchers, these guidelines provide exposure–response relationships that give insight into the expected health effects at observed or expected noise exposure levels. They offer recommendations on the maximum admissible noise levels for some sources and provide important input to assit in deriving the health burden from noise; in that sense, they can be used when producing studies such as noise maps and action plans to obtain an evaluation of the magnitude of the health problem. The systematic reviews developed in support of these guidelines allow practitioners to raise awareness of the credibility of the issue of noise as a public health problem and to use the recommended exposure–response relationships uniformly. Researchers will also benefit from the guidelines as they clearly identify critical data gaps that need to be filled in the future to better protect the population from the harmful effects of noise.
- The guideline recommendations provide a useful tool for national and local authorities when deciding about noise reduction measures, as they provide data to estimate the health burden on the population and therefore allow comparison among different policy options. These options

can include measures to reduce the noise emitted by the sources, measures aimed at impeding the transmission of noise from the sources to people and measures aimed at better planning the location of houses (urban planning).

- The guideline recommendations can also be used by civil society, patients and other advocacy groups to raise awareness and encourage actions to protect the population, including vulnerable groups, from exposure to noise.

Regarding noise abatement and mitigation of noise sources, practical exposure–response relationships for various noise sources are useful quantitative input to determine the impact of noise on health. They can be valuable information to use in cost–effectiveness and cost–benefit analyses of various policies for noise abatement. In this respect, the guideline recommendations can be an integral part of the policy process for noise reduction by various institutions; they are of great value for communicating the health risks and potential cost-effective solutions to reduce noise.

National and local authorities and nongovernmental organizations responsible for risk communication and general awareness-raising can use these guidelines for promotion campaigns and appropriate risk communication. The guidelines provide scientific evidence on a range of health effects associated with noise and facilitate appropriate risk communication to specific vulnerable groups. They therefore need to be promoted broadly to citizens, national and local authorities and nongovernmental organizations responsible for risk communication.

5.5 Methodological guidance for health risk assessment of environmental noise

A health risk assessment is the scientific evaluation of potential adverse health effects resulting from human exposure to a particular hazard – in this case, environmental noise. The main purpose of the assessment is to estimate and communicate the health impact of exposure to noise or changes in noise in different socioeconomic, environmental and policy circumstances.

The guideline recommendations, along with the detailed information contained in the systematic evidence reviews, can be used to assess health impacts in order to answer a variety of policy questions on:

- the public health burden associated with current or projected levels of noise;
- the human health benefits associated with changing a noise policy or applying a more stringent noise standard;
- the impacts on human health of emissions from specific sources of noise for selected economic sectors (and the benefits of policies related to them); and
- the human health impacts of current policy or implemented action.

The results from a health risk assessment are usually reported as the number of attributable deaths, number of cases, years of life lost, years lost due to disability or DALYs.

The quantification of the impacts for one combination of noise source, noise exposure indicator and health outcome may to some extent include effects attributable to another. Consequently, for any particular set of combinations, consideration should be given to potential double counting.

It is also important to note the uncertainties in quantification of the health impacts. One set of uncertainties relates to the CIs associated with the recommended ERFs; these quantify the random error and variability attributed to heterogeneity in the epidemiological studies used for health risk assessment. Other types of uncertainty include modelling/calculation of noise exposure, estimates of population background rates for morbidity and mortality, and transferability of ERFs from locations where studies were carried out or data were otherwise gathered to another location. This is especially true for noise annoyance, for which there is often considerable heterogeneity in effect sizes of studies because estimates vary between noise sources and are to some degree dependent on the situation and context. Furthermore, cultural differences around what is considered annoying are significant, even within Europe. It is therefore not possible to determine the "exact value" of %HA for each exposure level in any generalized situation. Instead, data and exposure–response curves derived in a local context should be applied whenever possible to assess the specific relationship between noise and annoyance in a given situation. If, however, local data are not available, general exposure–response relationships can be applied, assuming that the local annoyance follows the generalized average annoyance. Despite the challenges in applying a "generalized" ERF to specific local situations, the GDG believes that the percentage of high annoyance defined in section 2.4.3 is an acceptable estimate of the "average" %HA at a certain noise level – for example, in Europe.

When performing a health risk assessment of environmental noise, it is important to note several considerations. The selection of particular noise source(s), noise exposure indicator(s) and health outcome combinations to be used for estimation of the health impacts depends on the particular policies and/or measures being assessed. These guidelines propose recommendations for four types of noise source using noise indicators L_{den} and/or L_{night} (road traffic, railway noise, aircraft noise and wind turbine noise) and one recommendation using $L_{Aeq,24h}$ (leisure noise). Any population may be exposed to different noise sources associated with the same health outcome. Estimated impacts should not be added together without recognizing that addition will, in most practical circumstances, lead to some overestimation of the true impact. Impacts estimated for only one combination will, on the other hand, underestimate the true impact of the noise mixture, if other sources of noise also affect that same health outcome.

The scientific evidence reviewed and summarized in these guidelines implies that the following health outcomes can be quantified in a health risk assessment, and that their effects are cumulative:

- from road traffic noise – incidence of IHD, annoyance and sleep disturbance, and potentially incidence of stroke and diabetes;
- from railway noise – annoyance and sleep disturbance;
- from aircraft noise – annoyance, reading and oral comprehension in children, sleep disturbance and potentially change in waist circumference and incidence of IHD;
- from wind turbine noise: annoyance.

The DWs suggested in section 2.4.3 can be used to calculate DALYs.

Data on incidence and prevalence of some health outcomes related to noise (mainly cardiovascular disease) can be found at a national level in online databases available on the WHO Regional Office for Europe website (WHO Regional Office for Europe, 2017).

General principles of relevance for environmental factors when conducting health risk assessments and quantifying the burden of disease can be found elsewhere (European Centre for Health Policy, 1999; Murray, 1994; Murray & Acharya, 1997; Murray & Lopez, 2013; Quigley et al., 2006; WHO, 2014a; 2014b; WHO Regional Office for Europe, 2016). In particular, the WHO Regional Office for Europe and JRC jointly published the first estimates of the burden of disease from environmental noise in 2011 (WHO Regional Office for Europe & JRC, 2011). The publication includes guidance on the procedure for the health risk assessment of environmental noise, exemplary estimates of the burden of the health impacts of environmental noise and a discussion of the uncertainties and limitations of the procedure to calculate the environmental burden of disease. The reader is referred to this publication for more detailed explanations on quantitative risk assessment methods for environmental noise.

5.6 Route to implementation: policy, collaboration and the role of the health sector

Preventing noise and related health impacts relies on effective action across different sectors: health, environment, transport, urban planning and so on. The health sector needs to be engaged effectively in different sectors' policy processes at national, regional and international levels. It needs to provide authoritative advice about the health impacts of noise and policy options that will bring the greatest benefits to health.

In most countries in the WHO European Region, the commitment of the health sector to engage in action to address environmental noise issues needs to be improved and better coordinated. A more coherent overall response is needed, taking into account relevant linkages with existing health priorities and concerns. Thus, some actions can be seen as aspects of the role of the health sector:

- engaging in proper communication with relevant sectors about noise exposure from different sectors and sources (environmental, urban development, transport and so on) to ensure that health issues are adequately addressed as part of international, regional, national and/or local efforts to address environmental noise – the implementation approach may differ across sectors, depending on the level of awareness of noise as a public health problem;
- promoting the guideline recommendations to policy-makers from different sectors and organizing information campaigns and awareness-raising activities in collaboration with national health authorities and WHO country offices to inform citizens and health practitioners about the health risks of environmental noise;
- using decision support instruments such as health impact and health risk assessments to quantify health risks and potential benefits associated with policies and interventions aimed at addressing environmental noise, including presenting information about the severity of the health effects (for example, with cardiovascular disease) to convey the serious impacts of noise and to try to change attitudes and behaviours of policy-makers and the general public;
- promoting the guidelines to health practitioners and physicians, especially at the community level (through associations of physicians, cardiologists and so on as part of the stakeholder group);
- supporting the establishment of national health institutions capable of initiating and developing health promotion measures, and conducting research, monitoring and reporting on health impacts from environmental noise and its different sources;

- organizing capacity-building workshops and training to increase knowledge of the guidelines as well as creating tools, skills and resources for health risk assessment and developing intersectoral collaboration, particularly in non-EU countries;
- promoting relevant research initiatives and shaping the research agenda, in part based on critical research recommendations and gaps identified in the guidelines, as well as on the impact and effectiveness of interventions and experience with their implementation;
- developing and updating guidelines and policies that influence national, regional and international benchmarks and targets related to environmental noise, as well as advocating the inclusion of the guidelines in development and shaping of national, regional and international noise policies and standards;
- working with other sectors to strengthen noise level monitoring and evaluation, particularly in non-EU countries, to ensure proper conducting of health risk assessments of environmental noise.

5.7 Monitoring and evaluation: assessing the impact of the guidelines

Exposure–response relationships and other recommendations provided by these guidelines should be incorporated into national health policies and the main related policy documents. They should be used for health impact and health risk assessments to identify health risks and potential benefits associated with policies and interventions related to environmental noise.

Population noise exposure should be monitored and assessed at a national scale, at least in urban areas. Furthermore, information on trends in occurrence of noise-related health outcomes considered in these guidelines, such as annoyance or sleep disturbance, should be gathered. These monitoring activities should be performed on a regular basis to ensure proper health risk assessments of noise.

5.8 Updating the guidelines

The progress and pace of noise and health research has intensified over the last 10 years, including new studies published after the completion of the systematic reviews done for these guidelines. This is partly related to the growing car fleet and resulting traffic, the density of urbanization, demographic changes and shifts towards renewable energy, including wind turbines, which have caused an increase in public perception and political awareness of the environmental noise problem. Noise exposure assessment has also improved, due partly to European legislation, and this has provided useful data for epidemiological studies on the health effects of environmental noise. Considering this, the recommendations proposed in these guidelines are expected to remain valid for a period of about 10 years. WHO will monitor the development of the scientific advancements on noise and health research in order to inform any updated guidance on environmental noise.

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Annexes

Annex 1. Steering, advisory and external review groups

Tables A1.1–A1.5 give details of the various teams involved in the development of the WHO environmental noise guidelines for the European Region.

Table A1.1 WHO Steering Group

Name	Role	Affiliation
Shelly Chadha	Technical Officer, Office for Hearing Impairment	WHO headquarters, Geneva, Switzerland
Carlos Dora	Coordinator	WHO headquarters, Department of Public Health and Environment, Geneva, Switzerland
Marie-Eve Héroux	Technical Officer, Air Quality and Noise	WHO Regional Office for Europe, European Centre for Environment and Health, Bonn, Germany
Dorota Jarosinska	Programme Manager, Living and Working Environments	WHO Regional Office for Europe, European Centre for Environment and Health, Bonn, Germany
Rokho Kim	Environmental Health Specialist, Team Leader	WHO Regional Office for the Western Pacific, Division of Noncommunicable Diseases and Health through the Life-Course, Manila, Philippines
Jurgita Lekaviciute	Consultant, Noise	WHO Regional Office for Europe, European Centre for Environment and Health, Bonn, Germany
Srdan Matic	Coordinator, Environment and Health	WHO Regional Office for Europe, Copenhagen, Denmark
Julia Nowacki	Technical Officer, Health Impact Assessment	WHO Regional Office for Europe, European Centre for Environment and Health, Bonn, Germany
Elizabet Paunovic	Head of Office	WHO Regional Office for Europe, European Centre for Environment and Health, Bonn, Germany
Poonum Wilkhu	Consultant, Noise	WHO Regional Office for Europe, European Centre for Environment and Health, Bonn, Germany
Jördis Wothge	Consultant, Noise	WHO Regional Office for Europe, European Centre for Environment and Health, Bonn, Germany

Table A1.2. Guideline Development Group

Area of expertise	Reference	Area of expertise	Reference
Noise sources and their measurement	1	Annoyance	6
Biological mechanisms of effects	2	Cognitive impairment, quality of life, mental health and well-being	7
Cardiovascular and metabolic diseases	3	Adverse birth outcomes	8
Sleep disturbance	4	Environmental noise interventions	9
Hearing impairment/tinnitus	5	Methodology and guideline development	10

Name	Position and affiliation	Area of expertise sought for guideline development (see reference numbers above)									
		1	2	3	4	5	6	7	8	9	10
Wolfgang Babisch	Senior Scientific Officer (retired) Federal Environment Agency Germany		X	X		X					
Goran Belojevic	Professor Institute of Hygiene and Medical Ecology Faculty of Medicine University of Belgrade Serbia			X			X				
Mark Brink	Senior Scientist Federal Office for the Environment Switzerland	X			X		X				
Sabine Janssen	Senior Scientist Department of Sustainable Urban Mobility and Safety Netherlands Organisation for Applied Scientific Research (TNO) Netherlands				X		X				
Peter Lercher (2013–2014)	Professor Medical University of Innsbruck Austria							X	X		
Marco Paviotti	Policy Officer Directorate-General for Environment European Commission Belgium	X								X	
Göran Pershagen	Professor Institute of Environmental Medicine Karolinska Institute Sweden		X	X					X		

Table A1.2. contd

Area of expertise	Reference	Area of expertise	Reference
Noise sources and their measurement	1	Annoyance	6
Biological mechanisms of effects	2	Cognitive impairment, quality of life, mental health and well-being	7
Cardiovascular and metabolic diseases	3	Adverse birth outcomes	8
Sleep disturbance	4	Environmental noise interventions	9
Hearing impairment/tinnitus	5	Methodology and guideline development	10

Name	Position and affiliation	Area of expertise sought for guideline development (see reference numbers above)									
		1	2	3	4	5	6	7	8	9	10
Kerstin Persson Waye	Professor Occupational and Environmental Medicine The Sahlgrenska Academy University of Gothenburg Sweden	X			X		X				
Anna Preis	Professor Institute of Acoustics Adam Michiewicz University Poland					X	X				
Stephen Stansfeld (Chair)	Professor/Head of the Centre for Psychiatry Barts and Queen Mary University of London United Kingdom							X			
Martin van den Berg	Senior Noise Expert Ministry of Infrastructure and Environment Netherlands	X									
GRADE methodologist											
Jos Verbeek	Senior Researcher Finnish Institute of Occupational Health Finland	X									

Table A1.3. Systematic Review Team

Systematic review topics	Experts involved	Affiliation
Cardiovascular and metabolic diseases	Elise van Kempen	National Institute of Public Health and the Environment (RIVM), Netherlands
	Göran Pershagen	Institute of Environmental Medicine, Karolinska Institute, Sweden
	Maribel Casas Sanahuja	Institute for Global Health (ISGlobal), Spain
	Maria Foraster	Barcelona Institute for Global Health (ISGlobal), Spain and Swiss Tropical and Public Health Institute, Switzerland
Sleep disturbance	Mathias Basner	Department of Psychiatry, Perelman School of Medicine at the University of Pennsylvania, United States of America
	Sarah McGuire	Department of Psychiatry, Perelman School of Medicine at the University of Pennsylvania, United States of America
Hearing impairment and tinnitus	Mariola Sliwinska-Kowalska	Nofer Institute of Occupational Medicine, Poland
	Kamil Rafal Zaborowski	Nofer Institute of Occupational Medicine, Poland
Annoyance	Rainer Guski	Department of Psychology, Ruhr-University, Germany
	Dirk Schreckenberg	ZEUS GmbH, Centre for Applied Psychology, Environmental and Social Research, Germany
	Rudolf Schuemer	Consultant for ZEUS GmbH, Centre for Applied Psychology, Environmental and Social Research, Germany
Cognitive impairment, mental health and well-being	Charlotte Clark	Ove Arup & Partners, United Kingdom
	Katarina Paunovic	Institute of Hygiene and Medical Ecology, Faculty of Medicine, University of Belgrade, Serbia
Adverse birth outcomes	Mark Nieuwenhuijsen	Institute for Global Health (ISGlobal), Spain
	Gordana Ristovska	Institute of Public Health of Republic of Macedonia, the former Yugoslav Republic of Macedonia
	Payam Dadvand	Institute for Global Health (ISGlobal), Spain
Interventions	Lex Brown	Griffith School of Environment/Urban Research Program, Griffith University, Australia
	Irene Van Kamp	National Institute of Public Health and the Environment (RIVM), Netherlands

Table A1.4. External Review Group

Area of expertise	Reference	Area of expertise	Reference
Cardiovascular and metabolic diseases	1	Cognitive impairment, mental health and well-being	5
Sleep disturbance	2	Adverse birth outcomes	6
Hearing impairment/ Tinnitus	3	Environmental noise interventions	7
Annoyance	4	Recommendations and implementation guidance	8

Name	Affiliation	Area of expertise sought for guideline development (see reference numbers above)							
		1	2	3	4	5	6	7	8
Gunn Marit Aasvang	Norwegian Institute of Public Health, Norway		X						
Bernard Berry	Berry Environmental Limited, United Kingdom							X	
Dick Botteldooren	Department of Information Technology, Ghent University, Belgium				X				
Stephen Conaty	South Western Sydney Local Health District, Australia								X
Ulrike Gehring	Institute for Risk Assessment Sciences, Utrecht University, Netherlands						X		
Truls Gjestland	SINTEF, Department of Acoustics, Norway				X				
Mireille Guay	Healthy Environments and Consumer Safety Branch, Health Canada/Government of Canada, Canada		X		X				
Ayse Güven	Audiology Department, Faculty of Heath Sciences, Baskent University, Turkey			X					
Anna Hansell	Centre for Environmental Health & Sustainability, George Davies Centre, University of Leicester, United Kingdom	X							X
Stylianos Kephalopoulos	European Commission, DG Joint Research Centre, Italy							X	X
Yvonne de Kluizenaar	The Netherlands Organization for applied scientific research (TNO), Netherlands							X	
David S. Michaud	Healthy Environments and Consumer Safety Branch, Health Canada/Government of Canada, Canada		X		X				
Arnaud Norena	Université Aix-Marseille, Fédération de Recherche, Laboratoire Cognitive Neuroscience, France			X					
Enembe Okokon	National Institute for Health and Welfare, Finland								X
Dieter Schwela	Stockholm Environment Institute, University of York, United Kingdom								X
Daniel Shepherd	AUT University, Auckland, New Zealand					X			
Mette Sörensen	Danish Cancer Society Research Centre, Denmark	X							X
Rupert Thornley-Taylor	Rupert Taylor Ltd, Noise and Vibration Consultants							X	X
David Welch	School of Population Health, Faculty of Medical and Health Sciences, University of Auckland, New Zealand			X				X	

Table A1.5. Stakeholders and end users that participated in the stakeholder consultation

Area of expertise/interest	Reference	Area of expertise	Reference
Implementation of recommendations on railway noise	1	Implementation of recommendations on wind turbine noise	4
Implementation of recommendations on aircraft noise	2	Implementation of recommendations on leisure noise	5
Implementation of recommendations on road traffic noise	3	Implementation of overall recommendations	6

Organization	Area of expertise specifically sought for Guidelines (see reference number above)					
	1	2	3	4	5	6
Airlines for Europe		X				
Airports Council International Europe (ACI)		X				
Anderson Acoustics		X				
Bundesverband der Deutschen Luftverkehrswirtschaft e.V.		X				
European Automobile Manufacturers' Association (ACEA)			X			
European Aviation Safety Agency		X				
European Express Association	X					
European Noise Barrier Federation						X
Flughafenverband (ADV)		X				
International Air Transport Association (IATA)		X				
International Civil Aviation Organization (ICAO)		X				
International Union of Railways	X					
Landesamt fuer Natur, Umwelt und Verbraucherschutz Nordrhein-Westfalen						X
Public Health Agency of Sweden						X
Stephen Turner Acoustics					X	X
Union Européenne Contre les Nuisances Aeriennes		X				
Vie en.ro.se.						X

Note: in total 53 organizations and institutions had been approached to participate in the stakeholder consultation.

Annex 2. Systematic reviews and background documents used in preparation of the guidelines

Annex 2 provides a detailed list of all the supplementary documents accompanying the WHO environmental noise guidelines for the European Region.[22]

Systematic reviews

- Basner M, McGuire S (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(3):pii: E519 (http://www.mdpi.com/1660-4601/15/3/519/htm).
- Brown AL, van Kamp I (2017). WHO environmental noise guidelines for the European Region: a systematic review of transport noise interventions and their impacts on health. Int J Environ Res Public Health. 14(8). pii: E873 (http://www.mdpi.com/1660-4601/14/8/873/htm).
- Clark C, Paunovic K (2018). WHO environmental noise guidelines for the European Region: a systematic review on environmental noise and cognition. Int J Environ Res Public Health. 15(2). pii: E285 (http://www.mdpi.com/1660-4601/15/2/285/htm).
- Clark C, Paunovic K (in press). WHO Environmental noise guidelines for the European Region: a systematic review on environmental noise and quality of life, wellbeing and mental health. Int J Environ Res Public Health.
- Guski R, Schreckenberg D, Schuemer R (2017). WHO environmental noise guidelines for the European Region: a systematic review on environmental noise and annoyance. Int J Environ Res Public Health. 14(12). pii:1539 (http://www.mdpi.com/1660-4601/14/12/1539/htm).
- Nieuwenhuijsen MJ, Ristovska G, Dadvand P (2017). WHO environmental noise guidelines for the European Region: a systematic review on environmental noise and adverse birth outcomes. Int J Environ Res Public Health. 14(10). pii: E1252 (http://www.mdpi.com/1660-4601/14/10/1252/htm).
- Śliwińska-Kowalska M, Zaborowski K (2017). WHO environmental noise guidelines for the European Region: a systematic review on environmental noise and permanent hearing loss and tinnitus. Int J Environ Res Public Health. 14(10). pii: E1139 (http://www.mdpi.com/1660-4601/14/10/1139/htm).
- van Kempen E, Casas M, Pershagen G, Foraster M (2018). WHO environmental noise guidelines for the European Region: a systematic review on environmental noise and cardiovascular and metabolic effects: a summary. Int J Environ Res Public Health. 15(2). pii: E379 (http://www.mdpi.com/1660-4601/15/2/379/htm).

[22] All references were accessed on 27 June 2018.

Background documents

- Eriksson C, Pershagen G, Nilsson M (2018). Biological mechanisms related to cardiovascular and metabolic effects by environmental noise. Copenhagen: WHO Regional Office for Europe (http://www.euro.who.int/en/health-topics/environment-and-health/noise/publications/2018/biological-mechanisms-related-to-cardiovascular-and-metabolic-effects-by-environmental-noise).
- Héroux ME, Verbeek J (2018a). Results from the search for available systematic reviews and meta-analyses on environmental noise. Copenhagen: WHO Regional Office for Europe (http://www.euro.who.int/en/health-topics/environment-and-health/noise/publications/2018/results-search-for-available-systematic-reviews-environmental-noise).
- Héroux ME, Verbeek J (2018b). Methodology for systematic evidence reviews for the WHO environmental noise guidelines for the European Region. Copenhagen: WHO Regional Office for Europe (http://www.euro.who.int/en/health-topics/environment-and-health/noise/publications/2018/methodology-systematic-evidence-reviews-who-environmental-guidelines-for-the-european-region).

Annex 3. Summary of conflict of interest management

All external contributors to the guidelines, including members of the GDG, Systematic Review Team and External Review Group, completed WHO declaration of interest forms in accordance with WHO's policy for experts. Further, at the initial stage of the project WHO technical staff reviewed and accepted *curricula vitae* of the candidates for the GDG.

At the beginning of the GDG meetings, the participants declared any conflict of interest by submitting declaration of interest forms. Updated declarations of interest were also collected from the members of the GDG, Systematic Review Team and External Review Group at the final stage of the project.

The conflict of interest assessment was done according to WHO procedures. If a conflict was declared, an initial review was undertaken by the WHO Secretariat to assess its relevance and significance. A declared conflict of interest is insignificant or minimal if it is unlikely to affect or to be reasonably perceived to affect the expert's judgment. Insignificant or minimal interests are: unrelated or only tangentially related to the subject of the activity or work and its outcome; nominal in amount or inconsequential in importance; or expired and unlikely to affect current behaviour.

The WHO Secretariat reviewed and assessed the declarations. In one case the legal unit was consulted for advice; in another the potential conflict was reported in the updated declaration of interest at the final stage of the process and assessed unlikely to affect expert's performance; in a further case a member of the GDG was also a co-author of a systematic review owing to the need to support systematic review authors with additional expertise, but there was no remuneration for this activity.

No member of the GDG or the Systematic Review Team was excluded from his or her role in the guideline development process. The declared conflicts of interest of the External Review Group members were considered when interpreting comments during the external review process.

Annex 4. Detailed overview of the evidence of important health outcomes

As a first step of the evidence retrieval process, the GDG defined two categories of health outcome associated with environmental noise: those considered (i) critical or (ii) important, but not critical for decision-making in the guideline development process.

The GDG relied on the critical health outcomes to inform its decisions on priority health outcomes, so only these were used to inform the recommendations. Nevertheless, as the relevance of some of important health outcomes was difficult to estimate *a priori,* systematic reviews were conducted for both critical and important health outcomes.

This annex provides a detailed overview of the evidence of the important health outcomes – namely adverse birth outcomes, quality of life, well-being and mental health and metabolic outcomes – for each of the noise sources. A comprehensive discussion of all the evidence considered (both critical and important) is available in the published systematic reviews (see section 2.3.2 and Annex 2 for details).

1. Road traffic noise

1.1 Adverse birth outcomes

In total, the systematic review found five studies (two with more or less the same population) on road traffic noise and birth outcomes and three related studies on total ambient noise, likely to be mostly road traffic noise. Too few studies for each of the various measures related to adverse birth outcomes were available to undertake a quantitative meta-analysis. There was evidence rated low quality for a relationship between road traffic noise and low birth weight (Dadvand et al., 2014; Gehring et al., 2014; Hjortebjerg et al., 2016; Wu et al., 1996); however, the estimates were imprecise and in some cases not statistically significant. Further, there was no clear relation between exposure to road traffic noise and pre-term delivery, but there was a positive association between road traffic noise and small for gestational age (OR = 1.09; 95% CI: 1.06–1.12 per 6 dB increase). The evidence for both measures of adverse birth outcomes comes from the same publications and this evidence was rated low quality (Gehring et al., 2014; Hystad et al., 2014).

This evidence was supported by one ecological time-series study published recently looking at total ambient noise and various measures related to adverse birth outcomes (Arroyo et al., 2016a; 2016b; Diaz et al., 2016).

1.2 Quality of life, well-being and mental health

Evidence rated moderate quality was found for an effect of road traffic noise on emotional and conduct disorders in childhood (Belojevic et al., 2012; Crombie et al., 2011; Hjortebjerg et al., 2015; Ristovska et al., 2004; Stansfeld et al., 2005; 2009a; Tiesler et al., 2013) and evidence rated moderate quality for an association of road traffic noise with hyperactivity in children (Hjortebjerg et al., 2015; Tiesler et al., 2013).

There was no clear relationship, however, between road traffic noise exposure and self-reported quality of life (evidence rated low quality) (Barcelo Perez & Piñeiro, 2008; Brink, 2011; Clark et al., 2012; Honold et al., 2012; Roswall et al., 2015; Schreckenberg et al., 2010b; Stansfeld et al., 2005; 2009b; van Kempen et al., 2010); medication intake for depression and anxiety (evidence rated very low quality) (Floud et al., 2011; Halonen et al., 2014); depression, anxiety and psychological distress (evidence rated very low quality) (Honold et al., 2012; Stansfeld et al., 2009b); and interview measures of depression and anxiety (evidence rated very low quality) (Stansfeld et al., 2009b).

1.3 Metabolic outcomes

1.3.1 Diabetes

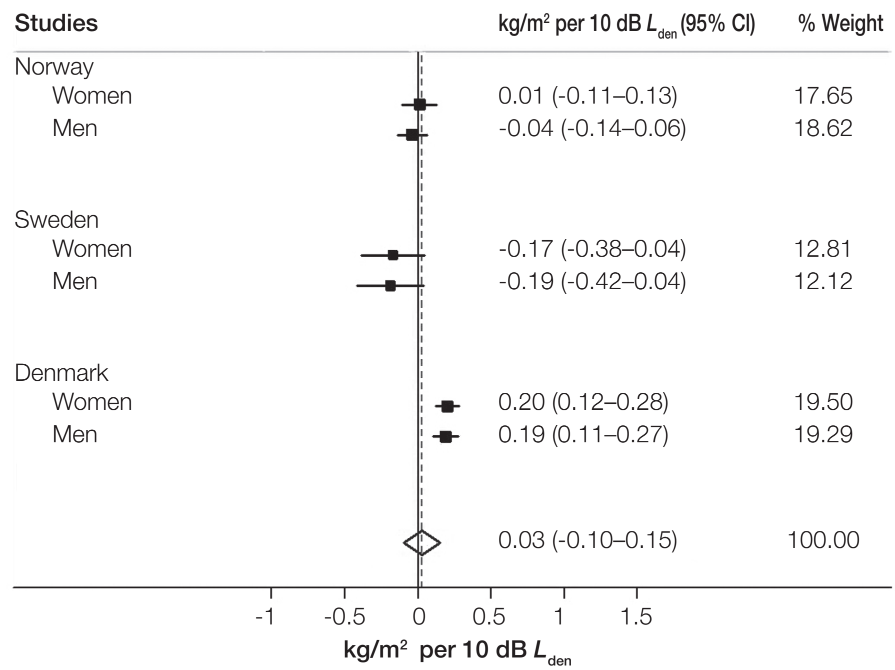
For the relationship between road traffic noise and the incidence of diabetes, one cohort study was identified, which included 57 053 participants and 2752 cases (Sörensen et al., 2013). The estimate of the effect was RR = 1.08 (95% CI: 1.02–1.14) per 10 dB L_{den} increase in noise across the range of 50–70 dB, and therefore the evidence was rated moderate quality.

Furthermore, two cross-sectional studies were identified that looked at the prevalence of diabetes (Selander et al., 2009; van Poll et al., 2014). The studies included 11 460 participants and 242 cases. Both studies reported a harmful effect of noise, and one showed a statistically significant association. However, the results were imprecise and with serious risk of bias, so the evidence was rated very low quality.

1.3.2 Obesity

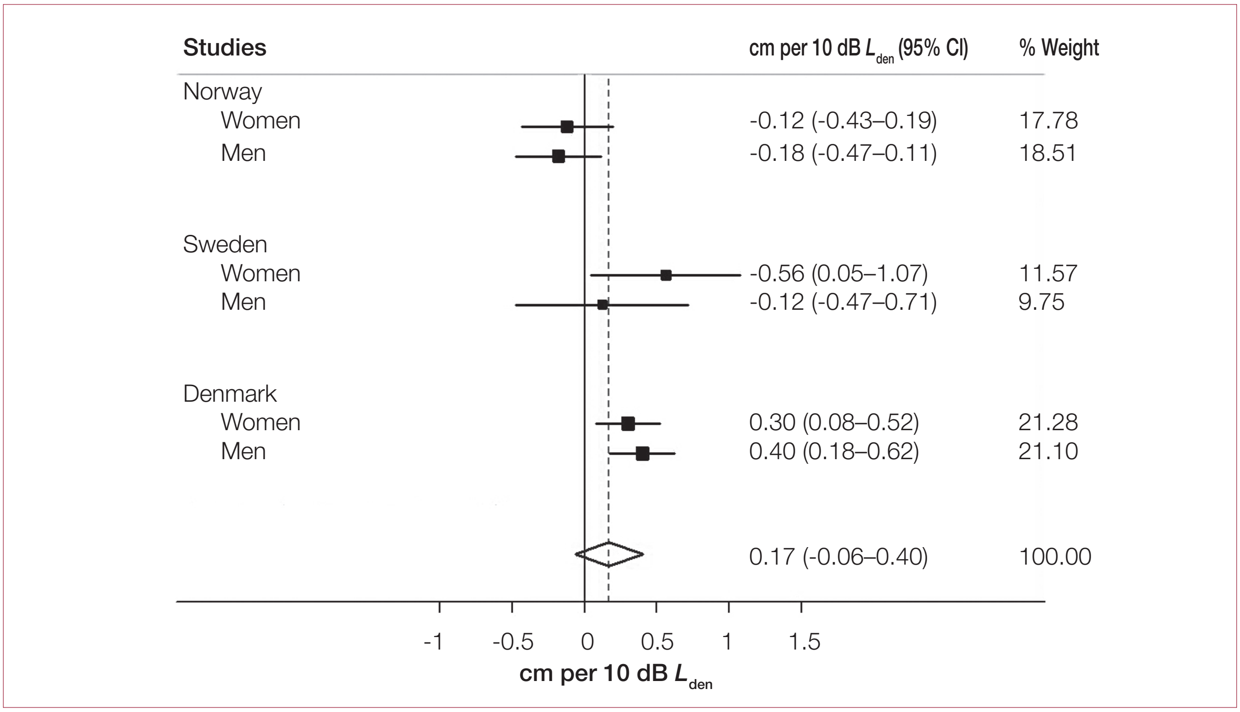
With regard to the association between road traffic noise and change in body mass index (BMI) and waist circumference, three cross-sectional studies were identified, with 71 431 participants (Christensen et al., 2016; Oftedal et al., 2014; 2015; Pyko et al., 2015). For each 10 dB increase in road traffic noise, there was a statistically nonsignificant increase in BMI of 0.03 kg/m^2 (95% CI: –0.10–0.15 kg/m^2) and in waist circumference of 0.17 cm (95% CI: –0.06–0.40 cm). There was inconsistency in the results between the studies; therefore, for both associations, the evidence was rated very low quality (Fig. A4.1 and Fig. A4.2).

Fig. A4.1 The association between exposure to road traffic noise (L_{den}) and BMI in three Nordic studies



Notes: The black vertical line corresponds to no effect of noise exposure. The black dots correspond to the estimated slope coefficients per 10 dB for each sex in each study, with 95% CIs. The diamond designates summary estimates and 95% CIs based on random effects models. The dashed red line corresponds to these summary estimates. Heterogeneity between studies: p = 0.000; heterogeneity between genders: p = 0.360; overall (I-squared = 84.4%, p = 0.000). Weights are from random effect analysis.

Fig. A4.2 The association between exposure to road traffic noise (L_{den}) and waist circumference in three Nordic studies



Notes: The black vertical line corresponds to no effect of noise exposure. The black dots correspond to the estimated slope coefficients per 10 dB for each sex in each study, with 95% CIs. The diamond designates summary estimates and 95% CIs based on random effects models. The dashed red line corresponds to these summary estimates. Heterogeneity between studies: p = 0.001; heterogeneity between genders: p = 0.842; overall (I-squared = 69.0%, p = 0.007). Weights are from random effect analysis.

2. Railway noise

2.1 Adverse birth outcomes

No studies were found, and therefore no evidence was available on the association between railway noise and adverse birth outcomes.

2.2 Quality of life, well-being and mental health

Evidence rated very low quality was found for a weak effect of railway noise exposure on self-reported quality of life or health, albeit from a limited number of studies (Roswall et al., 2015; Torre et al., 2007). There was evidence rated moderate quality for an effect of railway noise on emotional and conduct disorders in childhood (Hjortebjerg et al., 2015), but no clear relationship between railway noise and children's hyperactivity (Hjortebjerg et al., 2015); this evidence was rated moderate quality.

2.3 Metabolic outcomes

2.3.1 Diabetes

One cohort study was identified that looked at the relationship between railway noise and the incidence of diabetes (Sörensen et al., 2013). The cohort study of 57 053 participants, including 2752 cases, found evidence rated moderate quality that there was no considerable effect of railway noise on diabetes, with an RR of 0.97 (95% CI: 0.89–1.05) per 10 dB L_{den} increase in noise.

Furthermore, one cross-sectional study was identified that looked at the relationship between railway noise and the prevalence of diabetes (van Poll et al., 2014), including 9365 participants and 89 cases. An RR of 0.21 (95% CI: 0.05–0.82) per 10 dB L_{den} increase in noise was found, but the reasons for the beneficial effect were not immediately apparent. The evidence in the study was rated very low quality.

2.3.2 Obesity

Regarding the association between railway noise and change in BMI and waist circumference, two cross-sectional studies were identified, with 57 531 participants (Christensen et al., 2016; Pyko et al., 2015). Christensen and colleagues observed a statistically significant increase of 0.18 kg/m^2 (95% CI: 0.00–0.36 kg/m^2) per 10 dB for BMI and 0.62 cm (95% CI: 0.14–1.09 cm) per 10 dB for waist circumference in those exposed to railway noise, at levels above 60 dB L_{den}. Pyko and colleagues found a statistically significant increase in waist circumference of 0.92 cm (95% CI: 0.06–1.78 cm) per 10 dB L_{den}. The corresponding estimate for BMI was statistically nonsignificant, at 0.06 kg/m^2 (95% CI: –0.02–0.16 kg/m^2). The evidence was rated low/very low quality.

3. Aircraft noise

3.1 Adverse birth outcomes

Evidence rated very low quality was available for an association between aircraft noise and pre-term delivery, low birth weight and congenital anomalies, as evidenced by six studies included in the systematic review (Ando & Hattori, 1973; Edmonds et al., 1979; Jones & Tauscher, 1978; Knipschild et al., 1981; Matsui et al., 2003; Schell, 1981). The potential for risk of bias in these was high and the results tended to be inconsistent.

3.2 Quality of life, well-being and mental health

Evidence rated very low quality was available for an effect of aircraft noise on medication intake for depression and anxiety (Floud et al., 2011). There was evidence rated very low quality for an effect of aircraft noise exposure on interview measures of depression and anxiety (Hardoy et al., 2005) and rated low quality for an association of aircraft noise with hyperactivity in children (Clark et al., 2013; Crombie et al., 2011; Stansfeld et al., 2009a).

The evidence showed, however, no substantial effect of aircraft noise on self-reported quality of life or health (Clark et al., 2012; Schreckenberg et al., 2010a; 2010b; Stansfeld et al., 2005; van Kempen et al., 2010) or on emotional and conduct disorders in childhood (Clark et al., 2012; 2013; Crombie et al., 2011; Stansfeld et al., 2005; 2009a). This evidence was rated very low quality.

3.3 Metabolic outcomes

3.3.1 Diabetes

For the relationship between aircraft noise and incidence of diabetes one cohort study was identified, including 5156 participants and 1346 cases (Eriksson et al., 2014). The estimate of the effect was imprecise, with an RR of 0.99 (95% CI: 0.47–2.09) per 10 dB L_{den} increase in noise; the evidence was therefore rated very low quality.

Furthermore, one cross-sectional study was identified that looked at the prevalence of diabetes (van Poll et al., 2014), including 9365 participants and 89 cases. The RR was 1.01 (95% CI: 0.78–1.31) per 10 dB increase in aircraft noise. The evidence was rated very low quality.

3.3.2 Obesity

For the association between aircraft noise and change in BMI and waist circumference, one cohort study was identified, with 5156 participants (Eriksson et al., 2014). For each 10 dB increase in aircraft noise level, the increase in BMI was 0.14 kg/m^2 (95% CI: –0.18–0.45) (evidence rated low quality), and the increase in waist circumference was 3.46 cm (95% CI: 2.13–4.77) (evidence rated moderate quality). The range of noise levels in the study was 48–65 dB L_{den}. In the case of BMI, the change over the whole range in noise values was not statistically significant and was less than what could be considered clinically relevant (3–5% change in BMI); however, for waist circumference, the change was equivalent to an increase of 5.8 cm.

4. Wind turbine noise

4.1 Quality of life, well-being and mental health

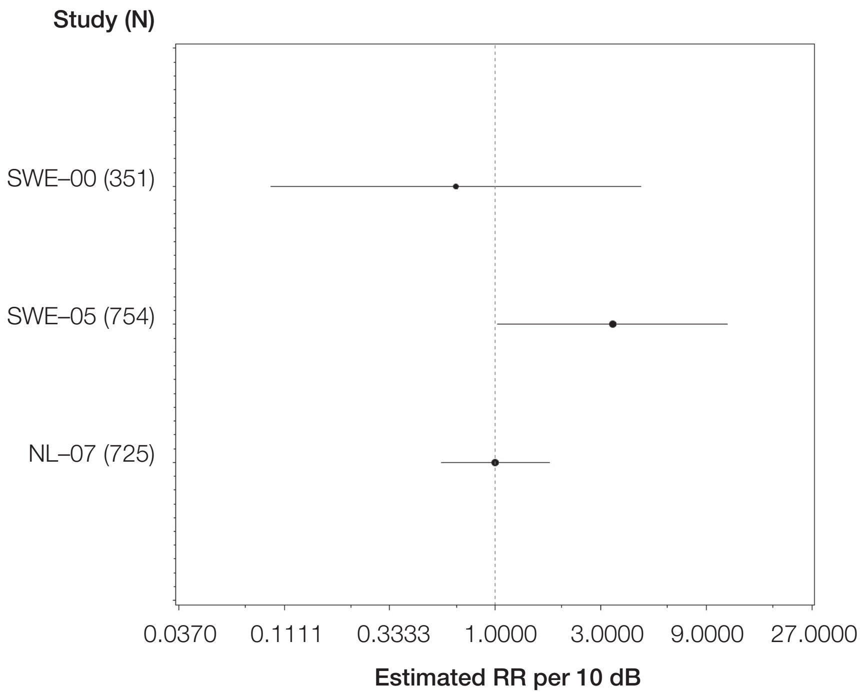
Five low-quality systematic reviews of wind turbine noise effects on mental health and well-being have been carried out (Ellenbogen et al., 2012; Kurpas et al., 2013; Merlin et al., 2013; Onakpoya et al., 2015; Schmidt & Klokker, 2014). These reviews differed in their conclusions and delivered inconsistent evidence that wind turbine noise exposure is associated with poorer quality of life, well-being and mental health. Therefore, the evidence for no substantial effect of wind turbine noise on quality of life, well-being or mental health was rated very low quality.

4.2 Metabolic outcomes

4.2.1 Diabetes

For the relationship between wind turbine noise and prevalence of diabetes, three cross-sectional studies were identified, with a total of 1830 participants (Bakker et al., 2012; Pedersen, 2011; Pedersen & Larsman, 2008; Pedersen & Persson Waye, 2004; 2007; Pedersen et al., 2009; van den Berg et al., 2008). The number of cases was not reported. The effect sizes varied across studies, and only one study found a positive association between exposure to wind turbine noise and the prevalence of diabetes; therefore, no meta-analysis was performed. Due to very serious risk of bias and imprecision in the results, this evidence was rated very low quality. As a result, there is no clear relationship between audible noise (greater than 20 Hz) from wind turbines or wind farms and prevalence of diabetes (Fig. A4.3).

Fig. A4.3 The association between exposure to wind turbine noise (sound pressure level) and self-reported diabetes



Note: The dotted vertical line corresponds to no effect of exposure to wind turbine noise. The black circles correspond to the estimated RR per 10 dB (sound pressure level) and 95% CI.
For further details on the studies included in the figure please refer to the systematic review on environmental noise and cardiovascular and metabolic effects (van Kempen et al., 2018).

5. Leisure noise

Owing to a lack of evidence meeting the critieria for systematic reviewing, no results for any of the important health outcomes can be given for exposure to leisure noise.

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The WHO Regional Office for Europe

The World Health Organization (WHO) is a specialized agency of the United Nations created in 1948 with the primary responsibility for international health matters and public health. The WHO Regional Office for Europe is one of six regional offices throughout the world, each with its own programme geared to the particular health conditions of the countries it serves.

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Noise is an important public health issue. It has negative impacts on human health and well-being and is a growing concern. The WHO Regional Office for Europe has developed these guidelines, based on the growing understanding of these health impacts of exposure to environmental noise. The main purpose of these guidelines is to provide recommendations for protecting human health from exposure to environmental noise originating from various sources: transportation (road traffic, railway and aircraft) noise, wind turbine noise and leisure noise. They provide robust public health advice underpinned by evidence, which is essential to drive policy action that will protect communities from the adverse effects of noise. The guidelines are published by the WHO Regional Office for Europe. In terms of their health implications, the recommended exposure levels can be considered applicable in other regions and suitable for a global audience.

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3 February 2015

Dear Sir Howard,

Airports Commission Consultation: Shortlisted Options for Additional Airport Capacity – Response from Kent County Council

Thank you for this opportunity to comment on the Airports Commission's appraisal of the shortlisted options for additional airport capacity. The responses to the consultation questions set out below convey Kent County Council's views on the proposals. Kent County Council's Cabinet agreed at a meeting on 1 December 2014 to oppose a second runway at Gatwick Airport, oppose the increase in overflights across West Kent as a result of airspace changes, and support a reduction in the number of night flights.

In terms of the second runway proposal, Kent will experience negative impacts in terms of increased aviation noise from more than a doubling of aircraft movements and suffer from a lack of respite provision with the use of both runways in mixed mode operations. Aviation noise in West Kent from Gatwick's current single runway configuration is already unacceptable and a potential doubling of this impact with a second runway would be intolerable. The noise impacts will be further exacerbated by the concentration of flight paths due to the implementation of the Future Airspace Strategy. This will inflict intolerable noise on communities with every single aircraft flying a single route on approach to the airport.

Government policy to limit and, where possible, reduce the number of people significantly affected by aircraft noise, should not result in a preference for aviation noise being inflicted on smaller populations in rural areas. Densely populated urban areas are noisy environments, whereas rural areas have low background noise levels and therefore aircraft noise is more intrusive. The tranquillity of the countryside around Gatwick, much of it part of Areas of Outstanding Natural Beauty (AONB), should be protected for both its amenity value close to Greater London and for the people who live there.

The current high number of permitted night flights at Gatwick (11,200 movements, almost three and a half times more than Heathrow's permitted 3,250 in the summer season) depriving people in West Kent of a decent night's sleep and negatively impacting on health is unacceptable to Kent County Council. The recent eastward shift of arriving flights joining the final approach over the Tunbridge Wells area, which have been focused by air traffic control into a narrower swathe, has caused considerable distress to the communities of West Kent; and this is also unacceptable to Kent County Council.

Significant investment in transport infrastructure is needed across the South East to cope with population growth. Although there has been investment in transport in London, the surrounding areas of the South East have not seen the level of investment required to accommodate growth. For example, in the Thames Gateway a new Lower Thames Crossing is needed to alleviate the capacity constraint on the existing crossing and help deliver housing and economic growth. The M25 is already severely congested and will require further capacity enhancements to accommodate the increased demand. Growth in London and the South East will put increased pressure on already strained infrastructure and this must to be considered alongside the increased demand from airport expansion; rather than merely assessing the needs of airport surface access in isolation.

A lack of adequate surface transport enhancements to accommodate the additional demand from a second runway at Gatwick will result in further congestion and delay on the strategic road and rail networks. This is in contrast with the planned step changes in surface access by rail to Heathrow, specifically through the provision of Crossrail, HS2 and Western Rail Access.

The negative impacts of Gatwick expansion are not outweighed by the direct economic benefits to Kent, to which there is very little evidence. Therefore;

Kent County Council is opposed to the proposed second runway at Gatwick Airport.

All prior submissions by Kent County Council to the Airports Commission, including proposals for additional airport capacity and responses to the Commission's Discussion Papers that indicated support for expansion of Gatwick are hereby rescinded.

Yours sincerely,

[redacted]

Paul Carter CBE
Leader of Kent County Council

Airports Commission Consultation:

Gatwick Airport Second Runway, Heathrow Airport Extended Northern Runway and Heathrow Airport North West Runway

Response from Kent County Council:

Q1: What conclusions, if any, do you draw in respect of the three short-listed options? In answering this question please take into account the Commission's consultation documents and any other information you consider relevant. The options are described in section three.

<u>Surface Access</u>

1.1 It is of some concern that Gatwick's second runway proposal is reliant on already planned and as yet uncommitted road and rail schemes that were intended to accommodate background growth. This extra capacity, intended for background growth, will be used up by airport related demand from the second runway.

1.2 When looking specifically at rail, the consultation document states in paragraph 3.26 that both planned and further uncommitted investment is needed on the Brighton Main Line to accommodate background demand growth in the 2020s. It is only if this extra rail capacity is delivered (intended to accommodate background demand growth) that there is expected to be the available capacity to accommodate passenger demand from a two runway Gatwick. However, even with the extra rail capacity there would be high levels of crowding in peak times, especially into London Bridge.

1.3 It is also stated in paragraph 3.26 that by the 2040s continuing growth in background demand is likely to require further investment to increase capacity on the London to Brighton rail corridor. The 2040s are likely to be a key period of growth as the airport reaches its maximum capacity by around 2050; therefore plans need to be in place to deal with this capacity issue on the Brighton Main Line otherwise there will be severe problems on this key rail corridor between London and the south coast.

1.4 The reliance on a single rail line to serve the airport does not provide any resilience or alternative rail routes. Together with the forecast background demand growth, it is questionable as to whether this is an appropriate rail access strategy for an airport proposed to grow to 96 million passengers per year, currently comparable to the biggest airports in the world.

1.5 The reliance on the London to Brighton Main Line rail corridor is further compounded by a lack of east-west rail links. There is a complete absence of a direct rail service to Gatwick from any Kent towns, e.g. Tonbridge. Kent County Council commissioned its own study into the business case for a direct Kent-Gatwick rail service, but this showed that the service would not be commercially viable and therefore not included in the Department for Transport's new rail franchise specification. However, if the airport is serious about spreading economic benefits across the South East rather than just being focused on the London corridor, and wants to achieve its 60% modal share target for access to the airport by public transport, Gatwick Airport Ltd should look into ways of providing funding towards these types of improved rail services. Otherwise, even more traffic will be on Kent's roads and on the motorways that pass through the county as people have no choice but to access the airport by car.

1.6 It is disappointing that the surface access appraisal does not consider east-west rail links and how this could have positive impact on the local economic appraisal, especially to Kent, the neighbouring county to Gatwick but is not really considered in terms of potential local economic impacts. Gatwick's local economic benefits seem to be very restricted to a north-south corridor.

1.7 In terms of road access, paragraph 3.28 of the consultation documents states that the appraisal concludes that planned and anticipated, although uncommitted, investment on the M23 and M25 is forecast to provide sufficient capacity to accommodate growth in demand from a two runway airport. However, this conclusion is challenged following analysis of the traffic modelling results in the Jacobs report 'Appraisal Framework Module 4 - Surface Access: Gatwick Airport Second Runway Final for consultation' (5th November 2014). Table 14 in that report clearly shows that demand on south-western sections of the M25 between junctions 7 and 10 will exceed 100% capacity by 2030 from background demand growth and demand from a single runway airport.

1.8 The model results in Table 14 show that the vehicle to capacity ratio (VCR) is made even worse with a two runway airport, for example, for trips to the airport between junctions 8 and 9 it will increase from 104% over capacity with a single runway airport to 108% over capacity with a second runway. This will therefore further degrade journey time reliability as levels of congestion worsen on this key part of the national strategic road network. Even though the proportion of airport related traffic from a second runway is minimal in comparison to the background growth; there still needs to be significant capacity enhancements to cater for that background growth (and the airport related proportion of that demand). This is needed in order for the network to function for all road users and provide reliable access to the airport (with or without a second runway). Therefore by 2030, additional capacity does need to be provided on the M25 to accommodate both background demand growth and to support the growth of the airport.

1.9 It should be noted that the extra capacity that has been created and included in the Core Baseline of the appraisal, for example, the extra lane on the south-eastern section of the M25 between junctions 5 and 7 from converting the hard shoulder for permanent running, was intended to meet background demand growth without consideration of the extra demand generated from a two runway Gatwick Airport. This extra capacity, which was intended to relieve existing levels of congestion and accommodate future background demand growth, will now be absorbed by the additional airport related demand from the proposed second runway.

1.10 As the appraisal concluded that there is likely to be sufficient capacity on the strategic road network, no costs were assigned to any network capacity enhancements. However, this conclusion is challenged and the costs of the capacity enhancements to the M25 on the south-western section (junctions 7 to 10), and ideally the south-eastern section as well (junctions 4 to 7), need to be established and added to the total cost of the project. The airport cannot function if it cannot be accessed efficiently due to congestion on the strategic road network, therefore, regardless of whether the capacity exceedance is due to the airport or not, extra capacity is needed to allow efficient road access to airport and to accommodate background demand growth. The costs of these improvements must be considered in the appraisal.

1.11 The issue of reliance on a single motorway connection (the M23) is stated in the Jacobs report as a concern by the Highways Agency as when a major incident closes the motorway there is no alternative. In similar way to the reliance on a single main line for access by rail, this is a serious shortcoming in the proposal to expand Gatwick.

1.12 As well as the strategic road network, there are likely to be additional traffic impacts upon local roads, in particular, the more characteristic rural lanes that cross the High Weald Area of Outstanding Natural Beauty (AONB) referenced in the AONB Management Plan. The additional traffic will also have wider implications such as air quality impacts and its impacts on people. The AONB Management Plan has targets (which have been adopted by Kent County Council) for improved transport sustainability. Therefore Gatwick's public transport offer should include provision of enhanced local bus services to towns across the High Weald AONB.

1.13 Comparing Gatwick's proposal with the two shortlisted options at Heathrow; as the Commission's analysis makes clear (stated in paragraphs 3.76 and 3.131), there are two major step changes in rail access which will occur regardless of whether Heathrow gets another runway or not. These are Crossrail and the HS2 connection from Old Oak Common. Crossrail will expand direct rail access from a range of destinations within and outside of London. The HS2 Old Oak Common link will provide rail access to the Midlands and the North.

1.14 In addition, Western Rail Access, which is also likely to happen regardless of a new runway, will provide direct rail connections to the West, e.g. to Reading and allows passengers from the west of the UK to access the airport without needing to interchange at Paddington station. The surface access strategies for both Heathrow options also include the proposed Southern Rail Access link to Waterloo. The appraisal concludes that although the airport will remain heavily reliant on the Great Western Main Line, an increasing variety of rail links, including the London Underground (Piccadilly Line), improves the resilience of rail access to Heathrow. This is unlike Gatwick, for which rail access is reliant solely on the Brighton Mainline.

1.15 In terms of road accessibility, the appraisal concludes that the majority of the strategic road improvements proposed to support the expansion of Heathrow are actually already needed even without a new runway; therefore airport development would bring forward the delivery of those schemes.

1.16 Clearly M4 widening and placing the M25 in tunnel are major obstacles that need to be overcome. It is urged that the western section of the M25, one of the busiest roads in the country, also gets a capacity upgrade when it is diverted into a tunnel below the proposed runway. Table 14 in the Jacobs report 'Appraisal Framework Module 4 - Surface Access: Heathrow Airport North West Runway - Final for consultation' (5th November 2014) shows that junctions 10 to 15 of the M25 exceed 100% the VCR from background growth only in 2030. Although this is made only marginally worse by including airport related demand from a two runway and a potential 3 runway airport; nevertheless, these capacity issues on the M25 need to be addressed to facilitate both non-airport trips and provide access to the airport via the national strategic road network.

1.17 The Jacobs report describes the impact of the additional runway as only a "*minor cause*" of the additional traffic and so there is "*no compelling case for the airport to be responsible for improvements to the network in these areas*". However, if congestion on the strategic road network inhibits passengers' ability to access the airport, this is a severe impediment to the airport's growth. Airport expansion should therefore take account of the limitations of the surrounding road network and work with the relevant public infrastructure body to enhance the network so that surface access to the airport is provided to an acceptable level.

1.18 However, in comparison with Gatwick, Heathrow's proposed expansion coincides with major step changes in rail access, e.g. HS2 and Crossrail, which are already planned; and road improvements that are needed anyway will be brought forward by the development of a new runway at Heathrow. In contrast, Gatwick is reliant on a single railway line and motorway with planned and further uncommitted schemes needed to cater for background growth providing sufficient capacity for airport related demand only until the 2020s; thereafter further investment will be needed in strategic surface transport infrastructure.

Strategic Fit

1.19 Heathrow is already operating at full capacity today, therefore providing capacity elsewhere, i.e. at Gatwick, will not solve the problem that currently exists at Heathrow. Heathrow is the UK's 'hub' airport and a second runway at Gatwick giving London two airports each with two runways, is likely to result in a sub-optimal solution for the UK's connectivity needs. The UK needs a strong 'hub' airport to connect to a range of markets, especially long haul "business" destinations in the emerging markets of the world economy – Brazil, Russia, India and China (BRIC countries). As stated in the consultation document, 84% of London's long haul market is at Heathrow, whereas Gatwick serves predominately short haul European destinations as demonstrated by the dominance of a low-cost carrier.

1.20 British Airways (BA) is committed to one hub at Heathrow and the major network airlines are all located there having invested in alliance specific terminals with Oneworld at Terminal 5, Star Alliance at Terminal 2 and SkyTeam at Terminal 4. It is unlikely these alliances would move their operations to Gatwick as only airlines that at the moment cannot get a slot at Heathrow look to the West Sussex airport as an alternative. The recent example of Vietnam Airlines moving from Gatwick to Heathrow demonstrates the continuing need for transfer passengers at a 'hub' airport to make the majority of long haul destinations viable. Long haul services in 'hub-busting' aircraft from an expanded Gatwick are only likely to be on the 'thickest' traffic routes; while new services to emerging markets are likely to still be dependent on pooling together transfer passengers.

1.21 Additional capacity being provided in the wrong location will not yield the optimal result for the UK's connectivity requirements. Stansted is an example of this as it remains half empty despite the capacity constraint at Heathrow. If creating capacity elsewhere was the answer to Heathrow's problem then Stansted with its spare capacity would be filling up with legacy airlines. There is no guarantee that with a doubling of capacity at Gatwick, airlines would switch their operations to where there is excess capacity. Gatwick may have a genuine business case for expansion to meet its own needs, however, to address the capacity constraint at the UK's principal 'hub' airport; capacity needs to be provided at Heathrow.

1.22 The potential for growth in air freight, vital for the modern UK economy, is limited at Gatwick due to the dominance of low-cost carriers which require quick turn-around times to minimise the time spent out of the air and do not include 'belly-hold' freight as a significant part their business model. As a result, cargo facilities at Gatwick are limited and as stated in paragraph 3.20 of the consultation document, any significant growth in the cargo sector at Gatwick would require significant investment in freight handling and forwarding facilities. In contrast, given the customer base of Heathrow with legacy carriers requiring 'belly-hold' freight for the viability of many long haul routes, expansion of Heathrow is likely to be highly beneficial to the air freight sector.

Therefore expansion of Heathrow would be more beneficial to the UK's economy in terms of air freight.

Economy

1.23 In terms of the economic impacts, expansion of the UK's 'hub' airport at Heathrow has the potential for greater economic benefit to the UK economy. The consultation document describes that the macro-economic assessment indicates that the wider economic benefits of expanding Heathrow, through either option, could have a GVA/GDP impact of between £101bn and £214bn (in present value 2014 prices) by 2050 depending on the growth scenario. This compares to a far lower range of £42bn to £127bn with expansion at Gatwick.

1.24 Kent appears to derive very little direct economic benefit from Gatwick despite its relatively close proximity to the airport. The West Kent districts of Sevenoaks, Tunbridge Wells and Tonbridge and Malling do not even feature in the appraisal's study area for 'local economy' impacts. Part of the reason is due to transport from Kent to Gatwick being poor, with road access dependent on the M25 with its congestion problems and unreliable journey times; and rail services being long and indirect via London due to an absence of east-west rail connectivity via Tonbridge and Redhill. As result, there is very little 'spill-over' of direct economic benefits to Kent from Gatwick despite its relatively close proximity to the county**.** As previously stated, Gatwick's 'local' economic impacts are very much focused on the north-south corridor from London to the south coast.

1.25 The lack of direct economic benefit to West Kent towns despite being in close proximity to Gatwick is exemplified by Edenbridge. The town is very near to Gatwick and suffers from aviation noise but appears to benefit little from business opportunities or jobs for young people associated with the airport. Gatwick's own analysis states that less than 1% of its work force is from any of the three West Kent districts of Sevenoaks, Tunbridge Wells and Tonbridge and Malling.

1.26 Gatwick Airport Ltd should be engaging with schools and colleges in West Kent to make young people more aware of the jobs and careers that are available to them through working at the airport. Local transport improvements to the airport are also needed so that these opportunities can be accessed by West Kent's communities. Local businesses need to be made aware of the opportunities, both through the supply chain and the benefit of access to global markets from being located near to a major international airport. Gatwick could also do more to promote the attractions of West Kent to overseas visitors passing through the airport so as to encourage visitor spend in the local area.

1.27 There is of course likely to be a trickle down of economic benefits to Kent from an expanded Gatwick. However, as previously stated, the Commission's own analysis shows that the wider economic benefits of an expanded Heathrow would yield far greater net benefit to the UK; and therefore likely a greater overall benefit to the Kent economy as a whole.

Cost and Delivery

1.28 The investment required to deliver a second runway at Gatwick will result in airport charges rising from the current £9 per passenger to between £15 and £18 with peak charges of up to £23 according to the Commission's analysis (paragraph 3.41 of the consultation document). While it is acknowledged that this is lower than the potential charges for expansion at Heathrow, Gatwick would lose its competitive advantage as peak charges of over £20 (Heathrow's existing charge) would result in a two runway Gatwick being as expensive as a two runway Heathrow (assuming Heathrow does not expand if the second runway at Gatwick is given approval). Gatwick's principal customers, low-cost carriers, may choose to relocate operations to airports with lower charges, e.g. Stansted, as Gatwick's offer no longer meets the needs of the low-cost business model.

Q2: Do you have any suggestions for how the short-listed options could be improved, i.e. their benefits enhanced or negative impacts mitigated? The options and their impacts are summarised in section three.

Master Plan – mixed mode operations

2.1 Gatwick Airport Ltd's proposal for a new runway with fully independent operation, i.e. independent mixed mode (both runways used for departures and arrivals); provides the maximum amount of additional capacity in terms of aircraft movements and passengers. However, it also has the most detrimental environmental and noise impacts with no opportunity for respite from runway alternation (one runway used for arrivals while the other runway is used for departures).

2.2 Mixed mode operation has never been accepted as a way to increase runway capacity at a two runway Heathrow, therefore it is unacceptable that mixed mode operations are an integral part of Gatwick's proposal for a two runway airport.

2.3 Mixed mode operations at a two runway Gatwick will subject West Kent to two parallel arrivals streams throughout the whole day, and potentially through the night as well if night flights continue to be permitted, with no opportunity for respite from runway alternation. Coupled with the concentration of flight paths through the use of precision navigation from the implementation of the Future Airspace Strategy, the noise disturbance would be intolerable.

2.4 The number of air transport movements is forecast to more than double from 251,000 in 2013 to up to 560,000 in 2050 with a second runway; and almost a tripling of passengers from 35 million passengers per year in 2013 up to a capacity limit of 96 million by 2050. This will transform Gatwick into an airport larger than Heathrow currently is in terms of both passenger numbers (72 million) and air transport movements (a planning cap of 480,000 movements).

2.5 If Gatwick is to be permitted to expand to a size comparable (or larger as proposed) to Heathrow, then a similar level of restriction on operational practices should be put in place to give people living under its flight path some form of protection. This should include the use of the runways only in alternating mode so that areas under each runway's arrival and departure routes get respite during the day from runway alternation.

<u>Noise – night flights</u>

2.6 Residents, who have to tolerate noise from aircraft over-flight all day long, should not also have to suffer at night with sleep deprivation and suffer the consequences of ill-health as a result. Ideally night flights should not be permitted other than in exceptional circumstances. Or at the very least, the number of flights permitted at night should be reduced to at least the level currently permitted at Heathrow. The number of permitted night flights at Gatwick compared to Heathrow is almost three and a half times greater in the summer and will be maintained at this level until 2017, due to the Department for Transport's (DfT) insistence on keeping the existing night flying regime for Heathrow, Gatwick and Stansted.

2.7 Any consideration of a second runway should be coupled with strict restrictions on the scheduling of night flights with a quota of minimal permitted movements.

Q3: Do you have any comments on <u>how</u> the Commission has carried out its appraisal? The appraisal process is summarised in section two.

3.1 No comments, the Commission has carried out a thorough appraisal.

Q4: In your view, are there any relevant factors that have <u>not been fully addressed</u> by the Commission to date? (section two)

4.1 Comments on factors that are considered to have not been fully assessed are related to the appraisal of specific topics and therefore are provided in response to the subsequent question.

Q5: Do you have any comments on how the Commission has carried out its appraisal of specific topics (as defined by the Commission's 16 appraisal modules), including methodology and results? (section three)

Environment – Noise

5.1 The Commission's interim report's recommendation for the creation of an independent aviation noise authority was welcomed as a step in the right direction towards addressing the lack of trust between communities affected by aircraft noise and the aviation industry.

5.2 This type of body is also needed to address the issue of the inadequate way that aviation noise is measured. In response to the Commission's discussion paper on noise in September 2013, Kent County Council emphasised that the method of measuring noise by use of the current 'average' LAeq metric does not accurately reflect how people experience aircraft noise. People's experience of aircraft noise is dependent on the volume of noise of each passing aircraft and the number of noise events experienced during the course of a day or night. The current use of the 57 decibel LAeq noise contour for measuring the onset of "*significant community annoyance*" (as defined in the Aviation Policy Framework) does not show the number of people who are impacted by noise from arriving aircraft many miles from the airport, such as the large parts of West Kent that are under the approach paths to Gatwick.

5.3 Kent County Council was therefore extremely disappointed by the Government's response to defer making a decision on whether to set up an independent aviation noise authority until after the Commission finishes its work this summer. This is action that needs to be taken now, regardless of where new runways are recommended.

5.4 It is welcomed that the appraisal used other methods of measuring noise which included the 'number above' ('N') contours which is a measure of the number of aircraft movements that exceed a threshold decibel level. The frequency of aircraft movements rather than the 'average' noise level has long been a concern across West Kent. However, use of the N70, i.e. number of aircraft movements that exceed 70 decibels, for the daytime measure and N60 (number above 60 decibels) for the night time measure, still omits most of West Kent from consideration of the noise impacts.

5.5 It was welcomed that the Kent settlements of Chiddingstone, Edenbridge, Hever and Marsh Green were included in the study area in the Jacobs report ('5.Noise: Local Assessment, November 2014'). However, the N70 contours do not impact these areas despite being under, or within close proximity to, the indicative flight paths of the proposed two runway airport. These areas are already impacted by aircraft noise from constant over-flight into Gatwick as a single runway airport. This is causing considerable distress to these communities and the situation is unacceptable to Kent County Council. For the appraisal to not even register these areas as impacted from either the existing runway or the proposed new runway is of extreme concern in terms of how aviation noise impacts are still being judged.

5.6 The use of 70 decibels as the threshold to record the number of incidences above this level is flawed. It is based on standards in Australia developed for Sydney airport; therefore it is questionable as to whether the 70 decibel level is appropriate for the rural areas surrounding Gatwick. Lowering this threshold to between 50 to 60 decibels for a single noise event would show that there are a significant number of flights across West Kent with noticeable noise impacts.

5.7 The more sensitive N60 measure, used for night time noise, does indeed show that the parts of Kent within the modelled area are within the contour of '25 to 50 events in an average annual night that exceed 60 decibels' with Gatwick's existing single runway configuration in 2030 (the 'do minimum scenario'). Given that the airport is already approaching its capacity limit in its current single runway configuration, it can be assumed that this is also already the case in the present day.

5.8 The upper end of this range equates to an average of more than one flight every 10 minutes throughout the night time period (23:00 to 07:00). This is an unacceptable situation and many residents of West Kent (also those that are far outside of the contours which only encompass more than 25 events per night) are being deprived of uninterrupted sleep; and therefore are at risk from the adverse health effects that sleep deprivation brings. Kent County Council has argued in response to the DfT consultation that the number of night flights permitted at Gatwick should be reduced to at least the lower number permitted at Heathrow.

5.9 The Jacobs study shows that with a second runway the N60 contours decrease in size and thus Kent is no longer within the '25 to 50' N60 contour. This is based on the assumption that there will be fewer flights at night due to the extra capacity created that can now be used in the daytime. This change is also reflected when plotting night noise contours the more traditional LAeq 8 hour metric. However, is there any evidence to suggest airlines will chose to reduce usage of the airport at night? The business model of low cost airlines (Gatwick's main customer) requires the maximum amount of aircraft rotations and therefore utilisation of all available operational time during the day and night.

5.10 Furthermore, long haul services often require take-off and landing slots at night in the UK due to the time difference at the origin or destination; and Gatwick's growth with a second runway will be involve more long haul services. Operational restrictions in the form of night movement limits and/or quotas are needed to turn this assumption of reduced night flights into a reality.

5.11 Regardless of the changes to the N60 contours at night, the very presence of the N60 contour in Kent demonstrates that when the lower N60 measure is used in place of the N70 contour, there are quantifiable noise impacts in West Kent. If the N60 contour was used for the daytime measure, the number of these noise events exceeding 60 decibels would be evident across the western part of the county. Aviation noise events exceeding 60 decibels are regularly experienced across West Kent and this situation would only be made worse with more flights due to a second runway.

5.12 Table 1 shows a snapshot of the noise experienced in Rusthall on the western side of Tunbridge Wells during a 30 minute period on a morning of westerly operations on 24 October 2014. The minute by minute measurements show noise events (Lmax) regularly exceeding 50, 60 or in some case 70 decibels in an area of background noise (Lmin) ranging from 30 to 40 decibels. When averaged out these levels of noise will not exceed the 57 decibel LAeq measure for what the Aviation Policy Framework considers to cause "*significant community annoyance*". However, it is the number of the noise events and the noise level of each event that causes annoyance to these communities in West Kent. Long term monitoring and modelling of these areas under the approach paths to Gatwick would show that the number and intensity of aircraft noise events is high enough to cause concern.

Table 1 Noise Measurements at Rusthall, west of Tunbridge Wells

File	Aircraft noise 061816_141024_102052000....		
Periods	1m		
Start	24/10/14 10:20:52		
End	24/10/14 10:52:52		
Location	Solo 061816		
Weighting	A		
Data type	Leq		
Unit	dB		
Period start	Leq	Lmin	Lmax
24/10/14 10:20:52	55.1	39.3	61.9
24/10/14 10:21:52	51.1	37.3	57.8
24/10/14 10:22:52	46.9	39.3	54.9
24/10/14 10:23:52	46.2	36.9	56.7
24/10/14 10:24:52	47.5	39.2	52.9
24/10/14 10:25:52	53.3	38.3	58.1
24/10/14 10:26:52	58.6	43.9	69.5
24/10/14 10:27:52	54.4	44.8	61.6
24/10/14 10:28:52	49.2	39.6	58.1
24/10/14 10:29:52	42.4	39.0	47.1
24/10/14 10:30:52	41.6	34.8	49.1
24/10/14 10:31:52	56.0	35.2	69.7
24/10/14 10:32:52	57.5	36.5	71.3
24/10/14 10:33:52	58.3	34.0	72.1
24/10/14 10:34:52	61.2	34.6	72.8
24/10/14 10:35:52	46.9	36.1	55.8
24/10/14 10:36:52	58.4	37.5	71.8
24/10/14 10:37:52	46.2	35.8	55.5
24/10/14 10:38:52	39.1	35.4	43.8
24/10/14 10:39:52	40.6	36.2	47.4
24/10/14 10:40:52	61.8	36.7	70.8
24/10/14 10:41:52	49.6	39.2	56.4
24/10/14 10:42:52	44.3	39.3	52.3
24/10/14 10:43:52	45.6	40.6	51.4
24/10/14 10:44:52	59.2	43.9	71.9
24/10/14 10:45:52	60.1	41.1	67.8
24/10/14 10:46:52	44.8	39.0	54.6
24/10/14 10:47:52	45.2	39.5	50.5
24/10/14 10:48:52	53.9	37.7	66.4
24/10/14 10:49:52	49.6	36.7	55.9
24/10/14 10:50:52	49.2	40.3	59.0
24/10/14 10:51:52	42.9	39.3	45.2
Overall	54.9	34.0	72.8

5.13 It is not only rural areas that are impacted by flight paths into Gatwick. The readings in Table 1 above are from an area to the west of Tunbridge Wells. The Borough of Tunbridge Wells has a population of 115,200, of which just over half live in the urban area. Nearby Tonbridge also has a population of over 120,000 spread through the Borough of Tonbridge and Malling. However, these statistics do not appear in the appraisal for Gatwick as they have not been modelled to be within the noise contours. Given the appraisal's emphasis on population densities and total numbers of people, these sizeable urban areas are not being incorporated into the absolute numbers of people affected by noise.

5.14 The appraisal's overall emphasis on population density and total numbers of people affected by noise does not therefore give equal consideration to rural areas of tranquillity with lower background noise levels. However, it is welcomed that the consultation document in paragraph 3.34 acknowledges that "*areas around Gatwick are rural and have high levels of tranquillity that would be adversely impacted by new development at the airport*".

5.15 Preserving the tranquillity of these areas is not only important for the people that live in these rural communities but it is also important for the tourism economy. Visitors to the Areas of Outstanding Natural Beauty (AONB) do so for peace and quiet and AONB close to London need to be protected from noise. Nationally significant heritage tourist attractions such as Hever Castle, Penshurst Place, Chartwell and Chiddingstone Castle are also negatively impacted by aircraft noise associated with Gatwick. This not only threatens the character of these historical places but also negatively impacts on visitor numbers and tourism spend in the rural economy.

5.16 Whilst forming part of the Guidance within the National Planning Policy Framework (NPPF), tranquillity is also a key element of landscape. In terms of the High Weald AONB, the impacts of additional noise may have an effect on the secondary purpose of the designation, which is to promote the public understanding and enjoyment of the landscape. With additional populations and rural areas being affected by noise with the expansion of Gatwick, people's experiences of the countryside may be compromised to a certain degree. Therefore the Gatwick second runway proposal impacts upon the experiential qualities of a nationally designated landscape.

5.17 The indicative flight plans used for the purposes of modelling the potential noise impacts are likely to be highly inaccurate based on the issues that Kent County Council, and other councils in West Kent, have come across regarding recent operational changes that have seen aircraft join the final approach further east of the airport over the Tunbridge Wells area. The Civil Aviation Authority (CAA), National Air Traffic Services (NATS) and Gatwick Airport Ltd have always been adamant that aircraft need to be established on the instrument landing system (ILS) final approach path by at least 10 nautical miles from the airport. This requirement would therefore seem to preclude the shortened approach paths indicated for the proposed second runway with aircraft only having turned and established on the final approach over Dormansland. If these shortened approaches are possible, it then becomes a question of why this cannot be done now for the existing runway and thus avoid flying over Kent on approach.

5.18 While it is acknowledged that the flight paths in the Jacobs study ('5.Noise: Local Assessment, November 2014') are only indicative, the alignment does control the geographical location of the modelled noise contours. This is demonstrated most acutely with the Lden contours which shift further west and south with a second runway. This is based on the assumption that the new flight paths are able to join the final approach to the second runway further west than they are with the existing runway. Different flight paths more aligned to the existing requirements, i.e. joining the final approach by 10 nautical miles, would result in different noise contour maps, with likely noise impacts for the second runway further east than is currently modelled. This would give a different outcome to the noise appraisal for the second runway. Flight paths need to be confirmed so that the noise impacts of the second runway can be more accurately ascertained.

<u>Environment –Biodiversity</u>

5.19 The Ashdown Forest is a characteristic part of the High Weald and biodiversity (habitats and species) is a fundamental part of the landscape's character. Biodiversity could be threatened by nitrogen deposition from an increase in vehicle traffic as a result of the proposal. The potential for impacts to the Ashdown Forest Site of Special Scientific Interest (SSSI) / Special Protection Area (SPA) / Special Area of Conservation (SAC) is broadly considered within the consultation report, in terms of the potential for increased nitrogen deposition on the sensitive habitats (with reference to a Wealden District Council report relating to a proposed programme of monitoring). However, it is concluded in the report that until monitoring results are published and a reassessment of ecological impacts carried out, there would be a neutral impact on this area in terms of emissions.

<u>Environment – Place</u>

Archaeology:

5.20 A second runway at Gatwick is unlikely to have direct impact on Kent's archaeological remains. However, there may be a more indirect impact from enabling or related works, such as improvements to infrastructure, especially improvements to the M25, A25, A21 or A264; or improvements to services, such as upgrading water, electricity, gas, telecommunication routes. The possible impact from related proposals cannot be identified at this stage but should be considered as a general issue.

5.21 There may be impact from additional over-flight on the setting of some archaeological sites, such as Squerryes Park Hillfort, in terms of appreciation and understanding of their site and situation.

Historic Buildings:

5.22 Increased flight numbers, especially of low-flying aircraft on approach to Gatwick, the increase in pollution from jet fuel and increased road traffic through Kent, may have an impact on the designated and undesignated historic buildings in the county. This could be particularly the case for the historic buildings within the high status residences, such as Squerryes Court, Chiddingstone and Chartwell. The historic buildings within the villages along the A25, such as Westerham and Brasted, and along the A264, such as Ashurst, could also be affected.

5.23 An indirect impact could be the detrimental effect on the setting of the more isolated but high status historic buildings, especially in terms of the impact on the understanding and appreciation of medieval and post medieval components. This impact on setting and on the buildings themselves, may lead to increase in restoration and maintenance costs and decrease in income generated from tourism, wedding venues, film locations etc.

Historic Landscapes:

5.24 The historic landscapes could be directly affected by the increase in over-flight and more indirectly by increased road traffic. The noise from aircraft would be intrusive and have a detrimental impact on the appreciation, understanding and enjoyment on the extensive designated parklands, some of which are major tourist sites in Kent. Historic landscapes are a key part of the historic character of Kent and the tranquillity of the historic areas are valued by residents and visitors. There might also be a detrimental visual impact on the views from and towards the historic parklands located on the hills, particularly towards the northern part of the West Kent area.

Summary of 'Place' impacts:

5.25 Although there may be only a localised direct impact on the archaeology, historic buildings and historic landscapes from works associated with the second runway at Gatwick, there may be considerable range of more indirect impacts from the increase in air traffic and the need to improve services for Gatwick. This could range from direct detrimental impact on the fabric of historic buildings from increased air pollution, to a more indirect impact on the appreciation of the quietness of surviving medieval landscapes. Assessment of the environmental impact of a second runway at Gatwick needs to be supported by a thorough and robust assessment of the historic environment and specialist assessment of archaeology, historic buildings and historic landscapes should be part of an Environmental Impact Assessment (EIA) process.

Q6: Do you have any comments on the Commission's sustainability assessments, including methodology and results? (section 2)

6.1 No further comments other than the issues raised in response to the previous questions.

Q7: Do you have any comments on the Commission's business cases, including methodology and results? (section 2)

7.1 No further comments other than the issues raised in response to the previous questions.

Q8: Do you have any other comments?

8.1 **In summary**, with a second runway at Gatwick, Kent will experience negative impacts in terms of increased aviation noise from more than a doubling of aircraft movements and suffer from a lack of respite provision with the use of both runways in mixed mode operations. Aviation noise in West Kent from Gatwick's current single runway configuration is already unacceptable and a potential doubling of this impact with a second runway would be intolerable. The noise impacts will be further exacerbated by the concentration of flight paths due to the implementation of the Future Airspace Strategy. This will inflict intolerable noise on communities with every single aircraft flying a single route on approach to the airport.

8.2 Government policy to limit and, where possible, reduce the number of people significantly affected by aircraft noise, should not result in a preference for aviation noise being inflicted on smaller populations in rural areas. Densely populated urban areas are noisy environments, whereas rural areas have low background noise levels and therefore aircraft noise is more intrusive. The tranquillity of the countryside around Gatwick, much of it part of Areas of Outstanding Natural Beauty (AONB), should be protected for both its amenity value close to Greater London and for the people who live there.

8.3 The current high number of permitted night flights at Gatwick (11,200 movements, almost three and a half times more than Heathrow's permitted 3,250 in the summer season) depriving people in West Kent of a decent night's sleep and negatively impacting on health is unacceptable to Kent County Council. The recent eastward shift of arriving flights joining the final approach over the Tunbridge Wells area, which have been focused by air traffic control into a narrower swathe, has caused considerable distress to the communities of West Kent; and this is also unacceptable to Kent County Council.

8.4 Significant investment in transport infrastructure is needed across the South East to cope with population growth. Although there has been investment in transport in London, the surrounding areas of the South East have not seen the level of investment required to accommodate growth. For example, in the Thames Gateway a new Lower Thames Crossing is needed to alleviate the capacity constraint on the existing crossing and help deliver housing and economic growth. The M25 is already severely congested and will require further capacity enhancements to accommodate the increased demand. Growth in London and the South East will put increased pressure on already strained infrastructure and this must to be considered alongside the increased demand from airport expansion; rather than merely assessing the needs of airport surface access in isolation.

8.5 A lack of adequate surface transport enhancements to accommodate the additional demand from a second runway at Gatwick will result in further congestion and delay on the strategic road and rail networks. This is in contrast with the planned step changes in surface access by rail to Heathrow, specifically through the provision of Crossrail, HS2 and Western Rail Access.

8.6 The negative impacts of Gatwick expansion are not outweighed by the direct economic benefits to Kent, to which there is very little evidence.

8.7 Therefore in conclusion, **Kent County Council is opposed to the proposed second runway at Gatwick Airport.**

Paul Carter CBE

Leader of Kent County Council

3 February 2015

UK Airspace Policy: A framework for balanced decisions on the design and use of airspace

Q1. Please provide your views on:

a. the proposed call-in function for the Secretary of State in tier 1 airspace changes and the process which is proposed, including the criteria for the call-in and the details provided in the draft guidance.

Kent County Council (KCC) has first-hand experience of the distress caused to communities by airspace changes outside of the presently notifiable/consulted on categories at Gatwick Airport. This has substantially eroded any trust the local communities had in Gatwick Airport, the Civil Aviation Authority (CAA) and NATS; and still some years on the damage has not be repaired. We therefore welcome the acknowledgement in the UK Airspace Policy "*that there should be suitable and proportionate levels of local engagement and transparency for the various types of changes that come about*." However, we disagree with the statement that "*it is not necessarily important to that community how the change came about*" because, in our experience, the local community want to know why an historical arrangement (and therefore one that is generally accepted) has been changed – especially where this is to a community's detriment.

Tier 1 changes (changes to the permanent structure of UK airspace) are already subject to the CAA's airspace change process. KCC responded to the CAA's consultation on the revised process and will also respond to the latest consultation on this. An Independent Commission on Civil Aviation Noise (ICCAN) would certainly strengthen the process and reassure local communities – provided that they are truly independent.

At present, the Secretary of State only has a role in Tier 1 changes where they detrimentally affect the environment, but it is unclear what circumstances meet this criterion. The new proposals for a call-in role are limited to airspace changes of strategic national importance, their impact on economic growth, and a change in the noise distribution. The noise change is very specific; requiring a net increase of 10,000 people "*subjected to a noise level of at least 54 dB LAeq 16hr as well as having an adverse impact on health and quality of life*." We believe that the noise criteria could, and should, be more generous. Firstly, it should include a criterion for night noise. The 54 dB level is above that recognised by the Department for Transport (DfT) in the night noise regime consultation for Heathrow, Gatwick and Stansted earlier in 2017. For consistency and acknowledgement of the most recent health impacts a 48 dB contour should be used. This will also offset some of the averaging effect that LAeq contours produce compared to frequency (N) contours.

Further, taking the net increase rather than assessing the number of people newly affected by aircraft noise will not accurately reflect the impact of airspace changes. This is especially true of rural areas where the ambient noise levels are low and any change to overflight is particularly sensitive. Furthermore, setting an arbitrary threshold of the number of people affected is not helpful and instead cases should be assessed on an individual basis. Other factors such as the presence of schools, heritage assets, environmentally designated sites, and so on; all have a substantial bearing on whether the noise impacts are acceptable. The Secretary of State should be able to use more discretion in deciding when to call-in a case.

We do not agree that the potential costs/delays and differing opinion of the CAA and Secretary of State are drawbacks of the proposals. Rather, the thorough examination in advance of airspace changes could reduce the potential workload if local communities are unhappy after a change has been made. Engagement and mitigation will be evidenced and the decision ultimately made by a democratically elected person rather than a designated body (i.e. the CAA) or a commercial sponsor (i.e. an airport).

b. the proposal that tier 2 airspace changes should be subject to a suitable change process overseen by the Civil Aviation Authority, including the draft guidance and any evidence on costs and benefits.

Tier 2 changes (planned and permanent changes to air traffic control day-to-day operational procedures) are one element of what was experienced by local communities around Gatwick Airport. The changing of the joining point to the ILS moved flights further east resulting in a concentration over areas of west Kent, including Tunbridge Wells. In our view this should be a Tier 2 change and should in future be consulted on and properly assessed for its impacts. This would be a vast improvement on the situation that did occur whereby the CAA and Gatwick Airport said there had been no airspace change and consequently infuriated communities who could clearly see (and hear) more flights, so we welcome the proposals for this process to change. The unsatisfactory nature of the current situation is recognised by the Government in stating it "*does not provide an appropriate level of transparency*" and that the noise impacts of a Tier 2 change can in fact be similar to that of a Tier 1 change.

The consultation document states that operational vectoring changes are likely to decline as precision based navigation (PBN) is introduced and defined routes are flown on departure and controller intervention reduced on arrivals. However, the PBN procedures themselves bring other problems. Notably, the 'natural' dispersal and respite is removed and an effect of overflight concentration is felt instead.

The proposals leave the Air Navigation Service Providers (ANSPs) to decide whether a proposal to amend vectoring practices could lead to a permanent and planned redistribution (PPR) of aircraft. Although this is relatively easy to define, it would nevertheless be prudent to have some independent oversight to check if all appropriate proposals are subjected to the Tier 2 process.

c. the proposal that tier 3 airspace changes should be subject to a suitable policy on transparency, engagement and consideration of mitigations as set out by the Civil Aviation Authority.

There is a need for transparency and engagement across all levels of airspace change. We appreciate that this needs to be proportionate but, nevertheless, mitigation may be possible and should be considered in all circumstances where safety permits it.

The suggestion that Airport Consultative Committees are used to inform communities of the impacts of such changes is useful. Other bodies should also be recognised, such as Local Authorities, Parish Councils and community groups. The statement that mitigation must be thought through with local communities to avoid unintended consequences is true. However, in the first instance the Tier 3 change itself must be discussed with local communities/their representatives to avoid any unintended consequences prior to consideration of mitigation. The UK Airspace Policy should also state this.

We welcome the proposals for the ICCAN to take a leading role in Tier 3 proposals and ensuring transparency across the industry.

d. the airspace change compensation proposals.

Paragraph 4.35 states that "*it is right that industry can seek to mitigate its impacts through compensation*." However, compensation is not in itself mitigation, but is rather a last resort in situations where the impact cannot be avoided. The current situation does not call for compensation until the equivalent of a doubling of aircraft movements has occurred, and only when new airport infrastructure is used rather than airspace changes. This is very restrictive and it is right that this should be reviewed.

The proposals state that the Government "would like airports and airspace change sponsors to look at examples at other airports to consider how their own compensation rules could be enhanced." Although we can appreciate the desire to ensure costs on the aviation sector are proportionate, it must be remembered that these changes primarily facilitate more efficient use of airspace and therefore more flights. These generate wider economic benefits but also profit for the airports. Fundamentally, commercial profits cannot come at a cost to the communities around airports who often do not experience the wider benefits. We therefore welcome the statement that the "*expected financial benefits of any airspace change will inform whether and at what levels compensation may be realistic*."

The use of options analyses to inform the fairest choice of route considering the compensation required by the different options has potential to encourage promotors to find the 'cheapest' option. The process needs to be validated – either by the CAA or ICCAN – to ensure that this has not been the case.

We are disappointed that the proposed National Noise Levy has not been taken forward and consider it appropriate to apply it to every airport, thereby avoiding any implications for State Aid. Such a fund could have made a meaningful difference to the quality of lives of residents affected by aircraft noise and ensure that all people have access to the same support regardless of what airport they are affected by.

We support the removal of the requirement for 3dB of change before financial assistance towards insulation is allowed. However, the use of the 63dB LAeq 16 hour contour should also be reviewed. The recent consultation on night noise regimes at Heathrow, Gatwick and Stansted used a 48dB 7.5 hour contour to reflect recent evidence on the noise levels that have negative health impacts. For consistency we think that the same metric should be applied here where airspace changes have noise implications at night. The 'financial assistance' should be full cost of insulation.

We also believe that a further criterion should be added to firmly make compensation applicable where overflight increases rather than the currently proposed scope, which is to *encourage* compensation. Where new settlements become overflown they will have transitioned from effectively no aviation noise to a level that is significant regardless of whether it meets the 63dB contour criterion because it would be hitherto unprecedented. If it is economically unviable to compensate then this is not the fault of the affected residents and would be something a National Noise Levy could have funded. Without this in place, then there should be funding from central government through ICCAN to compensate affected residents. We support the use of alternative metrics, such as frequency contours, but the threshold levels should be set fairly seeking expert advice based on health impacts and in consultation with ICCAN.

Q2. Please provide your views on:

a. the proposal to require options analysis in airspace change processes, as appropriate, including details provided in the draft guidance.

As per our response to the CAA's Airspace Change Process consultation (May 2016), we agree that the options analysis ('options appraisal' in the CAA consultation) will enable all stakeholders to consider the range of potential alternatives. This should be done in such a way that technical knowledge is not a prerequisite for understanding the analysis so that no stakeholders are in effect excluded. If new information, or consultation feedback, has a bearing on the analysis then it should be revised and reissued for further consultation.

It has long been our view that concentration of flight paths results in an untenable situation where certain settlements are intensively overflown compared to the previous situation where overflight was shared through the natural variation in choices made by pilots. Performance Based Navigation (PBN) allows precise routes to be chosen and flown and we believe that this technology could be better utilised to mimic the range of routes flown before its introduction. It is our policy (*Policy on Gatwick Airport*, 2014) that the use of multiple arrival and departure routes should be specified "*to provide predictable rotating respite and spread the burden of over-flight more equitably between communities*."

The noise policy is to limit and ideally reduce the number of people "significantly affected" by aircraft noise but there is no definition of what this means. The distribution of new routes around airports should ideally mimic the existing routes as far as practicable. Decisions on whether to use single routes or multiple routes, and assessment of the impacts of both, should be done in consultation with local communities and representative bodies. To this end, we welcome the approach specified that includes engagement with communities at its heart. This is part of the CAA's change process but should also function for all tiers of airspace change.

In general, airspace use that is as close as possible to the historical dispersal due to vectoring is what communities want rather than concentrated flight paths. At Gatwick, communities campaign for fair and equitable respite, which in practice means multiple routes in order to balance the benefits of modernising airspace and reduce the negative impacts on the ground. We acknowledge the difficulties that Gatwick's Noise Management Board have experienced in defining 'fair and equitable'. A combination of suitable metrics and discussion with the community bespoke to each situation will undoubtedly be necessary.

With regard to the constraints to what can be achieved in terms of noise, we agree that it would be unacceptable for large numbers of new people to be affected by noise. This would also apply to sensitive environments (such as Areas of Outstanding Natural Beauty) or heritage assets where they would be newly affected by noise in such a way that would damage their peaceful enjoyment or setting.

b. the proposal for assessing the impacts of noise, including on health and quality of life. Please provide any comments on the proposed metrics and process, including details provided in the draft guidance.

It is reassuring to see the proposals clarify the Government's objectives on limiting and where possible reducing the number of people significantly affected by aircraft noise – to avoid and mitigate the adverse impacts on health and quality of life, and to contribute to improving health and quality of life where possible. In our view, this puts noise at the centre of airspace policy.

We agree that N60 contours will help people affected to understand the implications of airspace change proposals. An average noise exposure (LAeq) contour is not as meaningful (or translatable into experience) as a contour showing the number of times a person will experience noise above a certain level.

We agree with the risk based assessment approach using the lowest observed adverse effect level (LOAEL). Using WebTAG will ensure consistency of approach across airspace change proposals and we welcome the ability to objectively compare proposals. However, taking one value of LOAEL at 51 dB LAeq 16hr in the day and 45 dB Lnight does not reflect the different situations of the airports across the country. Airports in urban environments, such as Heathrow, have a higher ambient noise level so 51 dB/45 dB may be appropriate, but Gatwick's rural location means that the ambient noise is very low and so annoyance, health and quality of life impacts will be felt at a lower level of aircraft noise.

The objective comparison of options should not ignore the subjectivity that is inherent in these situations – community concerns must be listened to. Therefore we support the inclusion of different metrics (including assessing frequency) to account for people who will be significantly affected below the LOAEL.

Q3. Please provide your views on:

a. the Independent Commission on Civil Aviation Noise's (ICCAN's) proposed functions.

We welcome the establishment of an Independent Commission on Civil Aviation Noise (ICAAN). The success criteria as set out in the proposals reflect the range of issues with which such a body can assist; with a credible and authoritative voice on aviation noise being particularly important. Recent changes in the use of airspace around Gatwick have severely eroded trust in the existing bodies and procedures for making such changes, including Gatwick Airport, the CAA, and NATS. It is, therefore, vital that ICCAN is truly independent and transparent in its operations.

As the proposals say, it is necessary to set up ICCAN at a suitable pace to enable it to lead on noise issues within airspace change modernisation and new runway capacity in the south east. We agree that using public funds is appropriate to enable this to happen, and in any case funding should be distinctly separate from the aviation industry. However, the proposed (but ruled out) Noise Levy would have been a suitable funding source.

We are concerned that there may be substantial areas of overlap between the work of ICCAN and the CAA so it would be useful to set up distinct guidelines on which body has responsibility for elements of noise monitoring and control. It may be that ICCAN can commission the CAA to develop best practice in new areas and verify/approve it for publication in the same way that is proposed for its research function. The advisory and influencing roles are important for ensuring consistency of mitigation and approach to avoiding noise across the country. It should be compulsory that airspace change sponsors give due regard to ICCAN's recommendations to ensure that their input is meaningful.

The monitoring and quality assurance function will only work if ICCAN has credibility as an independent body. We see the verification of noise forecasts and noise data as a key role for rebuilding trust in regards to aviation noise. It may be necessary for ICCAN to carry out its own data collection to compare to airport data, as well as commissioning experts. ICCAN must be suitably funded to carry out this function.

The Noise Management Board at Gatwick could be used as a model for bringing together varying interest groups to discuss noise issues. The experiences here will provide rich learning for the establishment of ICCAN.

b. the analysis and options for the structure and governance of ICCAN given in Chapter 6, and the lead option that the Government has set out to ensure ICCAN's credibility.

We are concerned that establishing ICCAN as an independent body within the CAA will inherently foster mistrust from the outset. As mentioned above, the communities around Gatwick have felt let-down by the CAA in recent changes to the use of airspace and therefore ICCAN's independence will be questioned. Whilst we recognise the advantages to the pace at which ICCAN can be established there must be a very clear separation between the two bodies. The transfer of expertise from the CAA to ICCAN will result in the same decision making and biases as the CAA, and only strong outside leadership will overcome this. We would also encourage ICCAN to utilise expertise from outside the CAA, such as consultancy support or academic researchers, to ensure that global best practice is being fully adhered to.

Once established, the Board and Commissioner should have authority and independence over the Secretary of State and the CAA to pursue a programme of work of its own choosing. Funding awarded to ICCAN should not be set conditionally but rather they should be able to decide how best to utilise those funds. It is appropriate, as proposed, to separate IT, data storage and website provision from the CAA. The appointment of the Commissioner will be crucial to the credibility of ICCAN based on how independent they are from the aviation industry. The Commissioner and/or or Board members should be considered from a wide range of areas, and we consider it appropriate to have representatives from a public health background particularly as noise reduces quality of life and lowers health outcomes.

The success of ICCAN for communities is based on its perceived independence. This should be given priority in any decision on how best to set up its structure and governance.

Q4. Please provide your views on:

a. the proposal that the competent authority to assure application of the balanced approach should be as set out in Chapter 7 on Ongoing Noise Management and further information at Annex F.

We agree with the proposal that the Secretary of State should be the appointed competent authority for Nationally Significant Infrastructure Projects and any called-in planning applications. Where the Local Planning Authority is the competent authority in all other planning-related operating restrictions then we would like to see suitable guidance and/or training available to ensure a consistency of approach across the UK. Currently the planning system is not designed for setting noise controls at airports and their ongoing review so guidance on how this will work in practice is urgently needed.

The Local Planning Authority that would be the competent authority does not usually have the same geography as the noise impacts of the airport concerned. For example, Gatwick Airport is within the planning remit of Crawley Borough Council who will have a view point informed by the economic benefits of a major employer in their area. Conversely, the West Kent authorities experience the negative impacts of overflight without receiving any of the economic benefits of the airport. The range of views of a number of authorities and communities must be considered many miles away from the relevant Local Planning Authority. We are not clear how the current proposals will ensure this is the case.

It seems appropriate to appoint the CAA as the competent authority for operating restrictions outside of the planning process. However, oversight from ICCAN would be welcome to ensure that trust is inherent in the system (subject to our comments above about the perceived independence of ICCAN if it is set up within the CAA).

The policy states that the future night flight regimes at the designated airports (Heathrow, Gatwick and Stansted) should be considered through planning or locally agreed. In our response to the recent consultation on the night flight regime we welcomed the possibility of having locally set restrictions but only subject to the full range of interested parties being consulted. Although night flights may not be a ‘significant’ decision in terms of the Government’s intervention, locally it is incredibly contentious and may be extremely challenging (if not impossible) to come to a local consensus. In this way, it would be preferable to have Government control instead of a protracted local discussion that could result in a worse scenario than would have happened under continued Government control. Although we note that the Government limits will remain the minimum standard.

b. the proposal that responsibility for noise controls (other than noise related operating restrictions) at the designated airports should be as set out in Chapter 7 on Ongoing Noise Management.

We disagree that the airports should be responsible for noise controls because they have a vested interest in the outcomes. The Department for Transport should retain oversight. We see a role for incentives for airports, and probably coordination by Consultative Committees or the Noise Management Board (in the case of Gatwick) as a forum to channel community concerns and ensure that airports address them. However, ICCAN’s best practice and Government’s agenda are not, in our opinion, significant incentives.

We are unclear what benefits and/or disbenefits transferring the ownership of the Noise Preferential Routes (NPRs) will have at the designated airports. As above, we believe that the Department for Transport should retain control of noise controls at the designated airports. The ability for airports to redesign the NPRs could prove advantageous but it is likely that the local communities will want to maintain the historic NPRs and the certainty they provide for the extent of overflight experienced. Airports could do this as an airspace change sponsor anyway without responsibility for noise controls.

c. the proposal that designated airports should publish details of aircraft tracks and performance. Please include any comments on the kind of information to be published and any evidence on the costs or benefits

The data that it is proposed the designated airports share would be useful for communities, particularly where they perceive a change in overflight or noise. However, the central issue is trust and so the data must be independently verified by ICCAN – which will be dependent on how independent it is perceived to be (as discussed above).

Again, the proposals call for airports to consult with their local communities on what data is published. Although the level of consultation does appear to be a burden on airports, in reality these conversations are likely to have been had already. Experience at Gatwick Airport has shown that GATCOM, NATMAG and the Noise Management Board have made requests for such data, which Gatwick have provided. Having a standard list of what data should be published and in what format would make the process of comparison year-on-year and airport-on-airport more straightforward and reduce the burden on airports to decide what and how they publish it.

d. whether industry is sufficiently incentivised to adopt current best practice in noise management, taking into account Chapter 7 on Ongoing Noise Management, and the role of the Independent Commission on Civil Aviation Noise in driving

We see a role for incentivisation but the proposals do not set out exactly what those incentives are beyond the current compliance mechanisms. Whether these are sufficient to see industry adopt best practice in noise management is something the Department for Transport, CAA and others should already be aware of. The recent Night Flight Regime consultation does not, in our opinion, go far enough to incentivise quieter aircraft because the proposals accommodate the current operations at the designated airports and do not necessitate a reduction in noise. The proposals, certainly for Gatwick, give room for growth and therefore more noise to the detriment of local communities.

The setting out of best practice is not in itself an incentive unless there are rewards for following it, or conversely penalties for not. The benefits of good publicity are inherently an incentive, with an industry example being Ryanair’s award for being the best performing airline at minimising its aircraft noise at Bristol Airport in 2016. This included being rated on departure track compliance and continuous descent approaches. Similarly, Stansted Airport won a National CSR Award for its work to reduce aircraft noise, also in 2016. A national scheme ranking airports on their work to reduce their noise emissions, including their work with local communities, would be one such idea to incentivise them. This could be run by ICCAN.

Differential charging by time of day is another means by which airports, and airlines, could be incentivised to adhere to best practice and reduce their noise impact. If the National Noise Levy had been brought forward the night time slots could attract a higher charge and consequently reduce the perverse current situation whereby aircrafts offer reduced landing fees at night as they have available slots. As the night flight quota limits still permit growth (certainly at Gatwick) this results in more noise throughout the day for residents.

Q5. The draft 'Air Navigation Guidance: Guidance on airspace & noise management and environmental objectives' reflects the proposals in this consultation, but the draft guidance will be reviewed in the light of the outcome of this consultation.

The aim of providing draft guidance on airspace and environmental management is to enable respondents who would like to understand how our policies would be implemented the opportunity to see draft guidance along with the high level policies when providing feedback

Please provide any comments on the Draft Air Navigation Guidance published alongside this consultation.

We hope to see the points we have made above taken into account in the next revision of the Air Navigation Guidance.

Department for Transport (DfT) Consultation – Night Flying Restrictions at Heathrow, Gatwick and Stansted Stage 2 Consultation

Response from Kent County Council

Kent County Council (KCC) welcomes the opportunity to respond to this consultation. Answers provided are in regards to Gatwick Airport as its associated flights affect parts of West Kent.

Q1: Do you agree with our preliminary view as to the new studies on health effects?

Kent County Council (KCC) does not agree with the preliminary view on the new studies on health effects, as although causality between noise and the risk of cardiovascular disease is statistically unproven, the impacts on people's lives of sleep disturbance from being awoken by aircraft noise is obvious for all affected. Therefore restrictions need to be put in place now, rather than wait for conclusions from continuing academic research.

Although further research is welcomed so that with robust evidence, the various impacts of aviation noise, including health effects, can be taken into account in economic appraisal alongside other costs and benefits; the very real and experienced impacts of sleep disturbance from aviation noise at night cannot be merely consigned to the appraisal process and weighed up against the economic benefits of night flights.

Q2: Do you have any further views on the costs and benefits, including health impacts, which we should take into account in our decision?

Health issues associated with night flight sleep disturbance should not be regarded as a cost benefit exercise in the appraisal process, but rather, a concern in its own right.

The linkages which have been made between sleep disturbance and health impairment, and the impact on productivity, are of real concern, despite causality remaining unproven. This is particularly relevant during the summer when people tend to sleep with their windows open and therefore the benefits of sound insulation are neutralised. Greater recognition must be given to the negative impact of noise on the health profile of communities who are affected by the concentration of night flights.

Night noise is perhaps the most unpopular aspect for the local communities to the east of Gatwick in Kent, specifically in the districts of Sevenoaks, Tunbridge Wells and Tonbridge and Malling. Although KCC recognises that maintaining the existing freedom of night operation enjoyed by Gatwick is crucial to the airport and the economy as a whole, there is a common belief by local communities, that night flights at Gatwick Airport are excessive, and that many residents are therefore denied the possibility "of a decent night's sleep". The situation is exacerbated by the absence of minimum height controls and noise controls for landing aircraft.

KCC therefore urges that more regard is given to the nature of impacts on people caused by continuous aircraft over-flight during the night around Gatwick; and not seek to confine the issue to a cost benefit analysis in appraising the impacts, which then influences the decision on the regulation of night flights.

Q3: Do you agree with the proposed environmental objectives?

The proposed environmental objectives do not go far enough in terms of measuring whether they are achieved.

Although the first objective to 'limit and where possible reduce the number of people significantly affected by aircraft noise at night', is an objective which we support; measuring its achievement by the area and number of people within the 6.5 hour night quota period contours, and in particular the 55dB contour, is not an adequate measurement method. It is acknowledged that the consultation document states that the World Heath Organisation considers average night noise levels above 55dB to be increasingly dangerous for public health. However, it is evident from experience in West Kent, where in areas outside of the average noise contours, aircraft over-flight at night (predominately arrivals) causes sleep disturbance for residents. Whether it is only 'dangerous' in terms of health at a certain decibel level is arbitrary, sleep disturbance is still detrimental to health if people are awoken by levels of noise lower than 55dB.

The noise impacts are further exacerbated by the largely rural nature of this area, the towns of Tunbridge Wells and Tonbridge not withstanding, where background noise levels, especially at night, are low compared to urban areas and therefore aircraft noise is considerably more intrusive. Some research argues that the noise differential in rural areas could be as high as 10 decibels because the background noise is lower.

The use of 'average' noise contours is in itself flawed, especially for measuring night noise disturbance, given that the noise from a single noisy overflying aircraft can cause someone to wake up regardless of the 'average' noise levels over a period of several hours. Even if one noisy aircraft does not cause an interruption to sleep, several aircraft might have this effect, but these conditions may still not register above the decibel threshold when measuring 'average' noise. Therefore Single Event Noise levels and the frequency (number of incidences) of that exposure should be the measure of compliance with this objective on the basis that it is noise from individual aircraft, not ‘average’ noise that causes sleep disturbance.

Although the second objective, to ‘reduce sleep disturbance resulting from use of the noisiest types of aircraft’, is an objective that KCC supports, its method of measurement does also not go far enough. Restricting the ‘number of movements of the noisiest types of aircraft (Quota Count [QC]/4 and above) during the night quota period’ needs to go further to extend the operational ban on QC/4 aircraft in addition to the proposed extension of the ban of QC/8 and QC/16 aircraft.

KCC does not support the third environmental objective to ‘allow growth in movements up to existing night movement limits and within noise quotas’, but rather that night movements should be reduced. The consultation document states that Gatwick currently uses only around 83% of its year round ATM limit; and uses on average only around 50 to 60% of its winter night noise quota count (QC) limit and 70 to 80% of its summer quota count. Therefore there is substantial scope for increased night flights within its permitted quota, which would not be acceptable to KCC.

Although KCC supports the intention of the fourth environmental objective to ‘encourage the use of quieter aircraft during the night quota period’, measurement through average QC points per movement, will not provide a realistic portrayal of the historic trends and a reduction of noise at source. Individual aircraft create noise at a certain level, some noisier some quieter, and the use of an ‘average’ is misleading. If there are only a few noisy aircraft that wake people at night, but the majority of aircraft are quieter, the ‘average’ will not reflect the fact that some noisy aircraft do operate and cause distress, and instead portray that on ‘average’ there is noise reduction at source.

Q4: Do you agree that the next regime should last until October 2017?

Agree that it is sensible that the next regime should last until October 2017 to cover the period of the Airports Commission publishing its recommendations on airport capacity and the Government making a decision on those recommendations. A subsequent review of the regime in 2016 (ready for new regime implementation in October 2017) should allow sufficient time for the Government to take account of the Airports Commission’s conclusions in summer 2015. The subsequent regime, post 2017, can then be aligned with the recommendations (if they are adopted) for use of airport capacity. This is particularly relevant with the recommendation in the Airports Commission’s Interim Report (December 2013) for the creation an Independent Noise Authority, which if implemented by the Government, would provide advice to the Department for Transport (DfT) in setting the next noise regime post October 2017.

Q5: Do you have any views on the revised dispensations guidance?

No comment.

Q6: Do you agree that we should maintain the existing movement and noise quota limits until October 2017? If not, please set out your preferred options and reasons – this could include the noise and economic impact of any alternatives.

Kent County Council (KCC), on behalf of its residents who are disturbed at night, would prefer that there were no night flights. However, KCC also recognises the economic arguments for allowing limited night flights, particularly long haul flights from emerging economies, which bring economic benefits to the UK.

However, KCC does not agree that the existing movement and noise quota limits should be maintained until October 2017, but rather that night movements and noise quota limits at Gatwick should be reduced in order to give residents under the flight paths, who are over-flown all day long as well as at night, are at the very least, allowed a decent night's sleep.

As previously stated, Gatwick currently uses only around 83% of its year round ATM limit; and uses on average only around 50 to 60% of its winter night noise quota count (QC) limit and 70 to 80% of its summer quota count. Therefore there is substantial scope for increasing night flights within its permitted quota, which as already stressed, would not be acceptable to KCC.

Gatwick's business aspirations are to compete with Heathrow; therefore it should be subjected to similar night noise restrictions as Heathrow. While it is acknowledged that night flying restrictions at Heathrow are tighter because of its surrounding urban environment, KCC urges that rural areas should also be given protection from night noise. This is especially relevant given that background noise levels are lower in the countryside compared to urban areas; therefore noise from aircraft over-flight is more noticeable in rural areas.

If Gatwick's night air traffic movement (ATM) limits remain set at 3,250 in winter and 11,200 in summer, this contrasts with far tighter night time movement controls at Heathrow (2,550 in winter and 3,250 in summer). Therefore Gatwick's air traffic movement (ATM) limit exceeds Heathrow by 27% in winter and is almost 3.5 times greater than Heathrow in summer. It is however acknowledged that Heathrow's noise quota count (QC) limit is higher than Gatwick in winter and only 18% less than Gatwick in summer, as this reflects the fact that long haul aircraft are larger and noisier at Heathrow and the airport is busier all year round, whereas Gatwick has a summer peak season and is served by generally smaller and supposedly less noisy short haul aircraft. Nevertheless, the number of movements (ATMs) permitted at night at Gatwick is greater than Heathrow and this should be made more equal between the UK's two biggest airports,

At the height of summer schedules, the frequency of landings at Gatwick through the sleeping hours can be as high as one very 6 minutes, e.g. on 8 July 2011 (source the Gatwick website). With the night ATM limit averaging at 61 ATMs per night in the summer, or one aircraft movement every 6.4 minutes, these high frequencies of aircraft over-flight are still within the permitted movement quota. Therefore in order for the situation for local residents to improve, there needs to be a reduction in the number of permitted movements at night.

Given that Gatwick is also currently operating at far below its permitted night noise quota count (QC) limit (at only 50-60% in winter and 70-80% in summer), there is the potential to increase the proportion of noisier aircraft that make up the number of night flights. Aircraft used on long haul routes are larger, and often noisier, therefore this is also likely to occur at Gatwick with the increasingly long haul nature of their operations, as the airport seeks to compete with Heathrow on long haul routes to emerging markets. This will also result in Gatwick having an increasing propensity to capture new early morning (night time) flights arriving from long haul destinations. Therefore the quota count (QC) limits for Gatwick also need to be reviewed.

Local communities must be protected from further increases in night flying and it is also not unreasonable for communities living alongside airports to seek a reduction in the number of night flights.

Q7: Do you have any comments on our forecasts to October 2017?

No comment on the forecasts. However, the use of 'average' noise contours is a flawed method of measuring the impacts of noise as people do not hear 'average' levels of noise; rather it is the noise from individual aircraft that wake people up at night. Use of area and population within 'average' noise contours does not represent those affected by noise outside of the contours. In the case of Gatwick, arrival noise affects a large area and many people who live under the approach paths but are far outside of the area of 'average' noise contours.

Q8: Do you have any views on how the benefits of quieter aircraft can be shared in the future between communities living close to the airport and the aviation industry?

Of particular annoyance at Gatwick is the high pitched "whining" tone of the airframe noise from the A320 group of aircraft. This has been investigated by the Environmental Research and Consultancy Department (ERCD) of the Civil Aviation Authority (CAA) and found that the tone is emitted at the 500-600Hz frequency and therefore is close to the peak sensitivity of the human ear. Close to the airport it is masked by other noise, but at around 7-15 nautical miles from the airport it is very audible. This is an example of aviation noise that may not be within the area of the 'average' noise contours, but affects people further out from the airport that live under the approach paths. This is particularly a problem in West Kent with arrivals into Gatwick. KCC urges that these aircraft are either retrofitted with equipment to prevent this high pitched "whine", or if this is not feasible, they should be banned in favour of quieter aircraft.

Although the faster phase-out of noisier categories of aircraft is sensible, the number of QC4 or above aircraft now being operated at night is, apparently, relatively small due to the scheduling ban between 23:30 to 06:00 (although the QC/4 ban is not proposed to be extended to the whole night time 23:00-07:00 period). Therefore more attention therefore should be given to the height and manner in which the aircraft are flown on their landing approach in order to reduce noise impacts.

Q9 (a): Do you agree with extending the operational ban of QC/8 and QC/16 aircraft to the entire night period (23:00 – 07:00)?

Agree with extending the operational ban of QC/8 and QC/16 aircraft to the entire night period (23:00-07:00). However, given that there were no QC/16 or QC/8 departures at Gatwick and considering that a QC/8 or QC/16 arrival is likely to belong to an older Chapter 2 aircraft which have been phased out; the time extension of the ban should go further and include QC/4 aircraft in order to have a meaningful impact.

The impact of one noisy aircraft at night can have knock-on effects on sleep disruption and deprivation, even though subsequent aircraft movements are made by quieter aircraft, on the saying that "once awake, always awake". Therefore the noisiest aircraft (including QC/4) should be banned, and the ban extended to the entire night time period (23:00-07:00) and not just the night time quota period (23:30-06:00). This is so that people are not prevented from getting to sleep in the 'shoulder' period between 23:00 and 23:30, or awoken too early (if that is the case) between 06:00 and 07:00.

Q9 (b): Do you agree with our assessment of the costs and benefits in the draft Impact Assessment?

Do not agree with the assessment of costs and benefits in the draft Impact Assessment as it does not consider the costs to local residents of keeping the existing night noise regime (it only considers it a benefit in terms of having night noise controls through a noise quota and movement limit identical to the previous regime). There is the potential to increase night flights at Gatwick due to the under-used quota which could be filled in the coming years of the new regime. Therefore this will subject local communities to increases in night noise above that which they currently experience, even though it is within the existing quota limit which is being maintained, and thus is not viewed as a change in policy option. Additional night flights will create productivity costs with local residents suffering from sleep disturbance as well as costs in term of health, although these are statistically unproven and have not been monetised.

Q10: Are there any other changes to the regime which we should consider?

None other than those already stated, i.e. a reduction in the number of permitted movements and noise quota for Gatwick so that it is of a similar magnitude to Heathrow.

Q11: Do you have any further comments on the scope for trialling new operational procedures which have potential noise reduction benefits in the period up to 2017?

KCC welcomes the inclusion of night time respite trials and was supportive of Gatwick's recent night arrivals respite trials. Although KCC also acknowledges that respite will bring benefits to some at the expense of others, and so there needs to be a clear justification for the areas that will benefit, to the detriment of others, from the alternation of flight arrival paths. However, thus far, we have not seen any analytical evidence of the benefits and disbenefits to communities under the two alternating flight paths. It is essential that the impacts on people, and not just operational improvements, are assessed in order to inform local stakeholders' views on the merits, or otherwise, of rotating respite at night, and at other times of day.

Alternating respite was a central part of the Gatwick Airport Ltd and NATS London Airspace Consultation with arrival and departure routes below 4,000ft and 4,000-7,000ft being re-designed from a 'swathe' to a single precision route (with an alternating precision respite route) using performance based navigation. The night flying regime, including the impacts on local communities of night time respite, must be taken into account once NATS has designed the new airspace routes following their consultation which closed on 21 January 2014, and before an airspace change proposal is submitted to the CAA.

KCC welcomes further work on increasing the angle of descent. There are observed major discrepancies in the heights with which individual aircraft approach Gatwick Airport, on a regular daily basis. Lower flying aircraft increases the quantum of noise overhead and the length of time over which the noise disturbance lasts is also extended the lower the aircraft flies. Therefore, the higher the aircraft pass overhead, the greater the benefit for the community and so we welcome this being delivered through steeper angle descents.

Paragraph 5.15 states that a night time runway preference scheme at Gatwick is not considered likely to have any great noise benefits. However, given that

Runway 26 operations with aircraft arriving from the east and landing into the prevailing westerly wind occurs 73% of the time, and high proportion of night flights at Gatwick are arrivals, West Kent gets over-flown by low flying descending aircraft during the majority of nights. Therefore, if there is an opportunity for a Runway 08 (easterly) preference when there are slight westerly winds below a certain speed, similar to runway direction preference procedures being tested at Heathrow; this should be investigated for Gatwick. This would provide some respite for people living to the east of Gatwick, whose current only form of meaningful respite from night time arrivals is from a change in wind direction, which happens on average only 27% of the time.

Q12: Are there any other matters you think this consultation should cover?

The differential between night and day landing charges, which heavily incentivises airlines to operate at night, and tourists (predominantly) to travel at night, should be challenged and discouraged. It is proposed that operators should be prevented from reducing or discounting landing fees during quiet periods, i.e. during the night. There is a general understanding that night landing fees at Gatwick are very much lower than daytime charges (due to greater available slots at these times), and that zero fees apply at certain times (due to excess capacity during the night), which is encouraging more discount night arrivals than is desirable. Gatwick's night fees should be higher than daytime fees to discourage night flights.

Also, airports should incentivise their clients by the use of favoured tariffs for quieter planes. Gatwick Airport's charges should be directly linked to a fee per measured decibel.

Q13 (a): Do you agree with the locations of the proposed new noise monitors at Heathrow? If not, are there alternative locations you would favour and why?

No comment.

Q13 (b): Do you agree with the proposal to apply runway-specific limit adjustments for easterly departures at Heathrow? If not, please give reasons.

No comment.

Impact Assessment Questions:

Question 1: Do you agree with our assessment of how movements and quota usage are likely to change over the period to the end of the summer season 2017 at Heathrow, Gatwick and Stansted?

In regards to Gatwick, the assumption of future growth based on historic growth rates during the high growth period is a sound methodology and as the forecasts show, it is unlikely that either movements or quota count will reach the existing limit/cap. However, as stated in response to earlier questions, the existing noise and movement limits do allow for significant permitted growth in night flights at Gatwick, which could occur if historic growth rates are exceeded in high growth assumption scenarios due to rapid economic growth during the recovery and an increase in demand for aviation. Such growth in night flights would be unacceptable in terms of night noise for people living under flight paths. Therefore the permitted number of night flights and night noise quota count limit should be reduced in order to protected residents from this potential increase in night noise over the coming years.

Question 2: Do you agree with our assessment of the costs and benefits of option 1 at Heathrow, Gatwick and Stansted? Would you expect there to be any additional costs and benefits?

As previously stated, we do not agree with the assessment of costs and benefits as it does not consider the costs to local residents of keeping the existing night noise regime (it only considers it a benefit in terms of having night noise controls through a noise quota and movement limit identical to the previous regime). There is the potential to increase night flights at Gatwick due to the under-used quota which could be filled in the coming years of the new regime. Therefore this will subject local communities to increases in night noise above that which they currently experience, even though it is within the existing quota limit which is being maintained, and thus is not viewed as a change in policy option. Additional night flights will create productivity costs with local residents suffering from sleep disturbance and costs to their health, although these are statistically unproven and have not been monetised.

Question 3: Do you agree with our assessment of the costs and benefits of option 2 at Heathrow, Gatwick and Stansted? Would you expect there to be any additional costs and benefits?

As previously stated, we agree with extending the operational ban of QC/8 and QC/16 aircraft to the entire night period (23:00-07:00) as in policy option 2. However, given that there were no QC/16 or QC/8 departures at Gatwick and considering that a QC/8 or QC/16 arrival is likely to belong to an older Chapter 2 aircraft which have been phased out; the time extension of the ban should go further and include QC/4 aircraft in order to have a meaningful impact.

The impact of one noisy aircraft at night can have knock-on effects on sleep disruption and deprivation, therefore have productivity costs and heath costs, (albeit not statistically proven or monetised), even though subsequent aircraft movements are made by quieter aircraft, on the saying that ‘once awake, always awake.’ Therefore the noisiest aircraft (including QC/4) should be banned, and the ban extended to the entire night time period (23:00-07:00) and not just the night time quota period (23:30-06:00). This is so that people are not prevented from getting to sleep in the ‘shoulder’ period between 23:00 and 23:30, or awoken too early (if that is the case) between 06:00 and 07:00.

[redacted]

David Brazier
Cabinet Member for Transport and Environment
Kent County Council

31 January 2014

By email:
night.flights@dft.gsi.gov.uk

Sessions House
County Hall
Maidstone
ME14 1XQ

28th February 2017

Dear Sir/Madam,

Department for Transport Consultation: Night Flight Restrictions at Heathrow, Gatwick and Stansted

This is Kent County Council's (KCC) response to the consultation by the Department for Transport (DfT) on proposals for revised night flight restrictions up to 2022. KCC has 84 elected Members representing approximately 1.5 million residents in Kent, and has substantial experience with aviation issues affecting our communities. In this regard, KCC regularly attends the Gatwick Airport Consultative Committee (GATCOM), and also responds to consultations from London Gatwick and London Southend as well as the Civil Aviation Authority.

In formulating this response, notification of the consultation was sent to all local Members in the areas affected by overflight from Gatwick asking for their views. KCC has an existing *Policy on Gatwick Airport* that was adopted by Cabinet in December 2014. This has also formed the basis of our response.

Turning to UK aviation policy more widely, we were very pleased with the long-awaited announcement of Heathrow as the preferred location for an additional runway. If additional runway capacity is not provided then London's connectivity will worsen compared to other global cities, which will in turn restrict the UK's economic prosperity. Further, with the current economic situation and uncertainty surrounding Brexit, it is increasingly important that London has links to emerging markets globally.

Building on the success of Heathrow will provide substantial benefits to businesses by connecting the UK with these world markets as well as increasing the choice of airlines and destinations for all passengers. Our airports discussion paper, *Facing the Aviation Challenge* (2014), extolled the benefits of better utilising our existing regional airports and this is something expansion at Heathrow will facilitate, distributing the economic benefits across the country.

As many of our residents in West Kent are adversely affected by aircraft noise from Gatwick Airport, I have great sympathy for those affected by the proposed expansion at Heathrow. However, the compensation package is generous, including 125% of full market value for homes (plus costs) and £700 million of noise insulation for homes and £40 million for schools and community buildings. In addition to this, the six-and-a-half hour ban on scheduled night flights will ensure that residents close to the airport, or overflown by aircraft using it, will experience a significant period of respite. Studies have shown respite to have substantial health benefits.

Currently, and in the proposals for the next regime, the night flight movement limit is much greater at Gatwick than at Heathrow, especially in the summer months. Heathrow is permitted 5,800 night-time take-offs and landings a year whereas at Gatwick it is 14,450. On a per night basis, this equates to approximately only 16 scheduled departures at Heathrow compared to 45 – 50 per night at Gatwick in the summer (18 – 20 in the winter owing to the seasonality of the airport). Further, the relatively recent changes associated with precision navigation at Gatwick resulted in a concentration of flight paths so that some residents get no respite. The impact of continuous overflight is unacceptable, especially at night, and communities cannot continue to suffer.

In the interim period before an additional runway is built, I am conscious that there is likely to be increased demand for night flights at Gatwick – either scheduled or owing to delays because of the airport operating at capacity. In the future, the proposed ban on night flights at Heathrow will put additional pressure on Gatwick and other London airports to accommodate those that can no longer use Heathrow.

Although this consultation on the night flight regime to 2022 will not see an increase in the permitted number of night movements at Gatwick, I strongly disagree with the fact that the proposals will not bring Gatwick's numbers in line with levels at Heathrow. Further, whilst it is proposed that the noise quota limits will be reduced at Gatwick, it will not be reduced by the same extent or to the same levels as Heathrow. In fact it will have a greater proportion of the total night flights in the London airport system with nearly double the noise quota limit of Heathrow in the summer. As a result, the surrounding communities will continue to suffer from this intolerable situation.

Moreover, once the third runway at Heathrow is operational, I can see no reason why the ban on night flights should not be extended to other London airports so that communities across the South East can benefit from the additional capacity at Heathrow.

With the above points in mind, the consultation questions are set out and answered below.

Yours faithfully,

Matthew Balfour

Cabinet Member for Environment and Transport

Consultation Document Questions

Q1a. How strongly do you agree or disagree with our proposed environmental objective for the next regime?

Tend to disagree.
The proposed objective to "*encourage the use of quieter aircraft to limit or reduce the number of people significantly affected by aircraft noise at night, while maintaining the existing benefits of night flights*" only targets the noise levels on average and not the frequency of individual incidents. Research shows that noise events leading to sleep disturbance causes health issues such as fatigue in adults and can affect children's educational attainment. Whilst we support the aim to encourage the use of quieter aircraft we would also argue most strongly that there should be greater restrictions on the number of night flights.

Q1b. Do you have any additional comments on our proposed environmental objective for the next regime?

Whilst it is wholly desirable to reduce the noise disturbance from night flights it is nevertheless the case that in rural and semi-urban areas (such as around Gatwick and Stansted) that any single incident of noise from aircraft may be substantially above background noise levels (even from those aircraft in the exempt category) and therefore disturbing to the communities that are affected. Further, the objective requires a definition of "significantly affected" as noise disturbance is a subjective matter.

We welcome the use of the 48dB $L_{Aeq\ 6.5hr\ night}$ contour instead of 55dB as this recognises new evidence about the impact of noise on sleep disturbance and health at a level below which was previously considered detrimental. Despite Gatwick's 48dB contour for the summer 2015 and winter 2015/16 season not extending into Kent, we know from the volume of complaints and communication we receive from residents that night flights still affect them as far east as Royal Tunbridge Wells.

The summer 2015 noise exposure contours published in January 2017 show that for the whole night period the 48dB contour extends to Chiddingstone – showing the impact that flights in the shoulder periods have on communities. The consultation document states that the Government recognises the economic benefits of night flights in terms of time-sensitive freight distribution. This does not apply to Gatwick. Figures from 2010 showed that Heathrow carries 86%[1] of UK belly-hold freight whereas Gatwick predominantly caters to low cost short haul carriers who do not transport freight. We argue that the volume of night flights is reduced as far as possible to a level comparable with Heathrow.

It is vital that the Department for Transport (DfT) recognises that measuring noise contours only assesses the average impact, which disguises the true variance of noise from Gatwick Airport. It only takes one event to disturb someone's sleep. Consideration should be given to this fact when setting the new regime.

[1] http://www.fta.co.uk/export/sites/fta/_galleries/downloads/air_freight/Skyhighweb.pdf

We support the QC/0 category aircraft counting towards the movement limit in the night period because this will ensure that there is transparency for communities in the total number of night flights they should expect.

As research into noise is furthered then the night flight restrictions should be reviewed, for example taking into account contours of annoyance or effects on educational attainment. Further research is particularly needed into the effect of individual noise events.

Q2a. How strongly do you agree or disagree with our proposal for the length of the next regime?

Agree.

Q2b. Do you have any additional comments on our proposal for the length of the regime?

We consider it appropriate to set the regime to 2022 at which point the work towards the proposed third runway at Heathrow would be substantially progressed. Additionally, we very much support the opportunity to agree bespoke arrangements with the airport locally – including outside of the planning process. This, however, needs to be carefully monitored so that any local agreement involves representation from all appropriate bodies so that the situation for individual communities is not any worse than would be the case under Government controls. Therefore, we will await the proposals for this method of setting controls in the forthcoming airspace policy consultation.

Q3a. How strongly do you agree or disagree with our proposal to introduce a new QC/0.125 category for aircraft between 81 and 83.9 EPNdB?

Agree.
These aircraft will still disturb people so it is sensible to capture them within the quota limit. Further consideration should be given to other new categories as research and technology improve.

Q3b. How strongly do you agree or disagree with our proposal for all aircraft quieter than this to remain QC/0 but count towards the airports movement limit?

Agree.
With regards to Gatwick Airport, airlines have orders for new aircraft (such as the Airbus A320neo) that will be quieter than the current QC/0.25 category. If these were to remain exempt from the movement limits as well as the noise quota limit then theoretically they could operate throughout the night period without restriction. Counting them towards the movement limit but not the noise quota (in combination with lowering the noise quota limit – see Q8a. and Q8b.) will incentivise the use of quieter aircraft but not increase the overall number of flights in the night period beyond what is currently permissible. This will improve transparency for communities affected.

However, although we agree with this principle, we would argue that the movement limit at Gatwick Airport should be substantially lower than as proposed – see Q5a. and Q5b.

Q3c. Do you have any additional comments on proposals for the Quota Count System?

We believe that with the commencement of the new regime the opportunity should be taken to ban QC/4 aircraft from the night period entirely, as is currently the case for QC/8 and QC/16 aircraft. Although at Gatwick there have been very few QC/4 aircraft used in recent years, those that are used generate a lot of unrest in the communities affected. In line with this approach, consideration should be given to a scheduling ban on QC/2 aircraft during the night quota period. These measures would encourage the use of quieter aircraft.

We also believe that the ability to carry over a proportion of unused noise quota and movement quota should be removed in the next regime. The current system results in uncertainty for communities and, because of the seasonality at Gatwick, effectively amounts to a higher summer limit.

Q4a. How strongly do you agree or disagree with the proposal for movement limits to remain unchanged at Heathrow?

As the Kent County Council area is unaffected by noise from night flights at Heathrow we defer to the relevant Local Authorities on this matter.

Q4b. Do you have any additional comments on our proposal for Heathrow's movement limit?

As the Kent County Council area is unaffected by noise from night flights at Heathrow we defer to the relevant Local Authorities on this matter.

Q5a. How strongly do you agree or disagree with the proposal for movement limits to remain unchanged at Gatwick?

Strongly disagree.

Q5b. Do you have any additional comments on our proposal for Gatwick's movement limit?

KCC's *Policy on Gatwick Airport* strongly opposes the current movement limits. In the summer months Heathrow is permitted 3,250 movements whereas Gatwick is permitted 11,200, or more than three times as many. Whilst we acknowledge that the two airports have different operating models, it is still unreasonable to expect the communities surrounding Gatwick to have an unfair burden on night flights compared to the remainder of the London airports system. This is particularly true in West Kent where the disadvantages of the proximity of the airport are felt but none on the economic benefits are received.

We note that the proposed inclusion of QC/0 aircraft in the movement limit is in effect a small reduction in the total allowance (in summer 2016 there were 53 movements by exempt aircraft) but also that the number of people affected by night noise has in fact increased since the last regime. This, in combination with the negative health impacts of night flights, presents a strong case for lowering the movement limit. Again, our policy states that numbers of night flights at Gatwick should be at least a level that is comparable with Heathrow and we ask the DfT to revise the proposed Gatwick movement limits downwards to begin to achieve this aim.

As stated above (Q3c.), we believe that the ability to carry over unused movements between seasons should be removed.

Q6a. How strongly do you agree or disagree with the proposal to raise Stansted's movement limits to reflect the current number of exempt aircraft in operation?

As the Kent County Council area is unaffected by noise from night flights at Stansted we defer to the relevant Local Authorities on this matter.

Q6b. Do you have any additional comments on our proposal for Stansted's movement limit?

As the Kent County Council area is unaffected by noise from night flights at Stansted we defer to the relevant Local Authorities on this matter.

Q7a. How strongly do you agree or disagree with our proposals to encourage the use of quieter aircraft at Heathrow?

As the Kent County Council area is unaffected by noise from night flights at Heathrow we defer to the relevant Local Authorities on this matter. However, we believe that quieter aircraft should be encouraged at all airports and so our comments in relation to Gatwick will also be relevant to Heathrow and Stansted.

Q7b. Do you have any additional comments on how you feel noise quotas can best be set in order to encourage the use of quieter aircraft at Heathrow?

As the Kent County Council area is unaffected by noise from night flights at Heathrow we defer to the relevant Local Authorities on this matter. However, we believe that quieter aircraft should be encouraged at all airports and so our comments in relation to Gatwick will also be relevant to Heathrow and Stansted.

Q8a. How strongly do you agree or disagree with our proposals to encourage the use of quieter aircraft at Gatwick?

Disagree – proposals should go further (see Q8b.).

Q8b. Do you have any additional comments on how you feel noise quotas can best be set in order to encourage the use of quieter aircraft at Gatwick?

The proposed noise quota has been set to ensure that the airport will not use more noise than at present if it uses its full movement quota (as Gatwick does in the summer). Whilst it is positive that this will prevent routes using noisier aircraft, the proposals in effect mean that the airport need not improve on its current performance. We believe that the proposals should go further and actively incentivise the use of quieter aircraft in the future. The suggestion in the consultation document of staggering a decrease in the noise quota over the years of the regime would achieve this and afford the airport and airlines time to change their operations and for new aircraft to come online.

We also ask that Government has taken into account the effect of the quota freeze on the noise performance of airlines so that the new regime accurately reflects what should have been achieved in the interim.

Even with the proposed reduction in noise quota in the winter, this still leaves substantial unused quota. In the winter 2015/16 season the total quota use was 953 and the proposal will make 1,655 the new limit. This leaves substantial room for growth considering that in the same period 1,872 movements counted against the limit of 3,250 and that will remain unchanged. Therefore, the current proposals for reducing the noise quota in the winter will have little, if any, effect and they should be revised downwards (as should the summer limits).

Q9a. How strongly do you agree or disagree with our proposals to encourage the use of quieter aircraft at Stansted?

As the Kent County Council area is unaffected by noise from night flights at Stansted we defer to the relevant Local Authorities on this matter. However, we believe that quieter aircraft should be encouraged at all airports and so our comments aircraft in relation to Gatwick will also be relevant to Heathrow and Stansted.

Q9b. Do you have any additional comments on how you feel noise quotas can best be set in order to encourage the use of quieter aircraft at Stansted?

As the Kent County Council area is unaffected by noise from night flights at Stansted we defer to the relevant Local Authorities on this matter. However, we believe that quieter aircraft should be encouraged at all airports and so our comments on in relation to Gatwick will also be relevant to Heathrow and Stansted.

Q10. Do you have any further views on our proposals, or their potential impact on the Government's ability to fulfil the requirements of the Public Sector Equality Duty?

No comments.

<u>Impact Assessment Questions</u>

We consider these questions more suitable for the aviation industry and cannot provide further evidence for your impact assessment.

Application by RiverOak Strategic Partners to upgrade and reopen Manston Airport
The Examining Authority's written questions and requests for information (ExQ1)

Kent County Council's Response

Reference	Question	Kent County Council's response
CA1.42	**Special Category Land -** The ExA is minded to recommend that the circumstances set out in s131(4) or 132(4) related to replacement land; 131(5) or 132(5) relating to area, or use and necessity of replacement land; 131(4A) or 132(4A) relating to availability of replacement land and public interest for a speeded procedure; or 131(4B) or 132(4B) relating to acquisition for a temporary purpose do not apply in relation to plots 185b, 185c, 185d, 185f. **Show any evidence to the contrary.**	KCC has no evidence to the contrary.
CA.1.43	**Special Category Land** PA2008 s132(3) states that this subsection applies if order land, when burdened with the order right, will be no less advantageous than it was before to the persons in whom it is vested, other persons, if any, entitled to rights of common or other rights, and the public. **Set out your reasoned opinion as to whether this subsection is fulfilled in the case of the Special Category Land at plots 185b, 185c, 185d, 185f**.	The County Council has looked at the plan and, other than highway land and a public right of way, does not appear to have any land affected within the plan. The County Council agrees that that the land will be no less advantageous to landowners or the public, even if the applicant obtains a right over the land.
DCO.1.2	**Article 12(2) – Temporary stopping up and restriction of use of streets** Article 12(2) in the draft DCO [APP-006] states that: "…*the undertaker may use any street temporarily stopped up or restricted under the powers conferred by this article and which is within the Order limits as a temporary working site*…"	KCC is not content with the wording of Article 12(2). The County Council requests that the wording is altered to require the applicant to seek written consent from the Highway Authority to be able to use the highway as a temporary working site. The County Council notes that utility companies, as statutory undertakers, have a right to access and maintain any plant. The *NRSWA 1991 Guidance on Measures necessary where apparatus is affected by Diversionary Works - A Code of Practice (appendix 1) states* that when a highway, which is subject of a stopping up order, contains undertakers' apparatus, the Highway Authority should be aware of the undertaker's need for adequate

	Is KCC content with this Article?	access or protection and should discuss the intended closure at an early stage. The statutory undertaker should be consulted with and given an opportunity to divert any mains/plant. With regards to permissions for access, once a stopping up order has been raised then this is no longer public highway and therefore in theory, any utility will not need to request road space from KCC as Highway Authority in order to access their plant/ apparatus. The wording should be altered to require the applicant to seek written consent from the Street Authority (i.e. the Highway Authority) to use the highway as a temporary working site.
DCO.1.4	**Requirement 16 – Archaeological remains** The ExA notes that the Relevant Representation from Kent County Council [RR- 0975] states that: "*a DCO requirement should cover the need to preserve the archaeology including through adjustment of development parameters as well as covering the necessary stages of evaluation and investigation. The requirements should also cover extensive investigation of those areas of the airport where archaeology will be affected by development but is not to be preserved in situ. The County Council welcomes the intention to agree a Written Scheme of Investigation for future archaeological investigations*." **Suggest any amendment to Requirement 16 that would satisfy the County Council in these respects.** **NOTE**: Kent CC may choose to answer this question in association with that at HE. 1.25	To achieve the preservation in situ that may be required, KCC will need to have clarified that there is indeed flexibility within the parameters of development - for example, the quantum of development in the Northern Grass Area as was claimed in discussions, but not set out in the DCO. KCC can provide some wording into Requirement 16 that allows for preservation following evaluation of those areas but would need to be sure that this does not counter the principle of the permitted development and make the requirement unworkable. It would be best to agree this requirement with Historic England.
E.1.8	**Incomplete surveys** Paragraph 5.4.17 of the ES [APP-033] states: *"Although complete surveys have presently not been possible, sufficient information exists*	Incomplete archaeological surveys introduce an increased risk that important archaeology will be later found in the development site and that will not be able to be preserved within the agreed parameters of the development and its design. The significance and harm to the built heritage assets of the site is also not fully set out and addressed in the DCO

	whereby the following has been applied. Where survey information is absent, a realistic worst-case approach has been adopted to what might be found had all the surveys been carried out, based on desktop surveys, analysis and site surveys undertaken. This is coupled with a commitment to carry out further surveys once access to land has been obtained, whether through voluntary agreement or compulsory access following the making of the application, or should the DCO be granted, access once ownership of the land has been obtained." **What limitations and uncertainty do NE, EA, KCC and HE believe these incomplete surveys introduce into the EIA?**	submission and potentially development could result in the loss of important built heritage assets.
Tr.1.5	The ES Volume 15 Part 1 [APP-060] Para 3.2.1 notes that "*At the time of the preparation of this TA, a formal request to use the model has been made, and a detailed scoping methodology is soon to be provided to KCC. However, the model was not ready to use before the submission of this DCO application*." **i. Is the model yet ready and, if so, will it be used in the production of further traffic analysis?** **ii. When would this further work be made available to the ExA?** **iii. Please confirm what the impact of the modelling work is on the ES traffic and transport assessment and linked assessments such as air quality and noise.**	The County Council, as Local Highway Authority, considers that it would be useful at this point to clarify the chain of events leading to the statement within ES Volume 15 Part 1. KCC currently feels that this element in the ES is partly misleading. Throughout the pre-application process, the applicant had stated to the County Council their intention to utilise the Thanet Strategic Highway Model (KCCSHM) to assess their development proposal with respect to highway matters. This extends back to pre-application discussions that took place on in August 2017, leading up to 21 December 2017 (which was the final correspondence that KCC received from the applicant's consultants prior to the formal submission of the subsequently withdrawn version of the DCO). During this time, the KCCSHM was unavailable for use as it was being refined in order to inform the emerging Thanet Local Plan, however the applicant was informed by the Highway Authority that the KCCSHM would likely to be available from January 2018 onwards. Following consideration of the Thanet Local Plan in January 2018, there was a period of almost four months between an initial expression of interest from the applicant for access to the KCCSHM and the submission of the DCO. This provided an opportunity for the

		applicant to instruct the Highway Authority to commission the necessary modelling work prior to submission of the DCO, however no further contact was received from the applicant during this period. In the absence of an agreed future position regarding the Thanet Local Plan, the Highway Authority encouraged the applicant to engage with the Local Planning Authority to agree an appropriate future land use scenario in relation to the DCO application, however to KCC's knowledge, very limited/no dialogue was progressed. Following this, it was concluded by the applicant that the timeline of model availability did not align with its deadline for DCO submission. It is the opinion of the Highway Authority that simply because the appropriate tool for assessing the impact of the development proposal is unavailable for a specified period, does not automatically render an alternative approach (in this case the method utilised within the current ES Volume 15) as acceptable or appropriate. It is the opinion of the Highway Authority that the submission of the DCO application should have been delayed until the appropriate highway assessment tools were available, to avoid a situation where alternative highway impact assessments and mitigation strategies were a requirement post submission or during the formal examination. The Highway Authority can confirm that a formal instruction to commission Strategic Modelling services was received from the applicant on the 25 October 2018. This was then followed by a further request for additional modelling services towards the end of November 2018. All relevant outputs from the KCCSHM were completed by the Highway Authority (through their appointed transport consultants) to the satisfaction of the applicant in December 2018. The purpose of the KCCSHM is to provide a robust set of traffic forecasts to inform more detailed individual junction modelling assessment (to be undertaken by the applicant). This would then provide the necessary traffic impact data to inform an appropriate highway mitigation strategy in line with the submitted Thanet Local Plan. It is important to highlight that the modelling undertaken (under the instruction of the applicant) assumes that the

		development which is subject to the DCO has no material impact on local housing needs/projections. Please note that this does not mean that KCC endorses or opposes that assertion at this stage. The modelling outputs from the KCCSHM suggest that there is some material disparity between the traffic conditions that were forecast within the current Transport Assessment (forming part of the ES). Some of these disparities are outlined within the KCC Local Impact Report. To date, the Highway Authority has not been informed by the applicant of when further detailed junction modelling assessments will be completed or submitted for comment. Moreover, it is unclear which format this information will be submitted in. The disparity in traffic flows identified between the KCCSHM and the spreadsheet modelling submitted to inform the current Transport Assessment has the potential to instigate a change to the scope of highway junction assessment and the form of mitigation required at individual junctions/links. Therefore, this supports the assertions made by the Highway Authority in relation to the need for KCCSHM to be used to provide robust and appropriate traffic data to reach an informed position on appropriate highway mitigation strategy.
Tr.1.6	The ES Volume 15 Part 1 [APP-060] Para 3.2.3 asserts that "*Spreadsheet modelling is an acceptable approach and the methodology is set out in this TA*." This assertion needs to be justified. **Does KCC agree with it?**	This question is partly addressed in paragraph 4.1.3 to 4.1.6 of the KCC Local Impact Report Appendix. The County Council considers that it is important for the traffic impact assessment to be undertaken consistently in line with the emerging Thanet Local Plan evidence base (including the Thanet Transport Strategy) to enable a consistent approach to highway mitigation to be considered within the district. It is evident that the development trip assignment methodology that has been used to inform the submitted Transport Assessment (which includes the "Spreadsheet modelling" approach) is principally based upon the Google real-time online journey planner tool. This method is sometimes employed by transport professionals to assess likely vehicle routing in the absence of more locally specific modelling tools. However, this approach is not capable of reflecting the considerable changes in trip assignment arising from future

		development, traffic growth and associated transport mitigation measures. It simply assesses the existing road conditions and associated journey times to identify a quickest route for trips from expected origin to destination. The KCCSHM is dynamic in the way that it assesses traffic distribution/routing and will consider the impact of increased traffic volume to new and existing journeys on the local road network. It is also capable of forecasting the impact of new highway infrastructure such as new or improved road links or road closures. The submitted Thanet Local Plan growth includes plans for several new highway links and improvements in the locality, therefore the KCCSHM is considered to the appropriate tool for assessing the future impact of the proposed development. This has been communicated to the applicant at various stages prior to the submission of the DCO.
Tr.1.13	**a) Do TDC and KCC agree with the scope of cumulative projects considered in the transport assessment [Section 10, APP-061]?** b) **What information does KCC consider is available to assess the impact of a Thanet Parkway Station on 2039 traffic flows?**	a) The County Council considers that the scope of proposed improvements that have been included within Section 10.1 do not represent the full extent of highway improvements that are planned in line with the most recent revision of the Thanet Transport Strategy (this document has been both developed and endorsed by Kent County Council and Thanet District Council). Notable omissions are: - • An additional new road link between Shottendane Road and Hartsdown Road, through housing allocation (H02 - Land north and south of Shottendane Road, Margate within the emerging Thanet Local Plan). • An additional road link between Shottendane Road and The A28 Canterbury Road, through the proposed strategic housing allocation (SP15 - Westgate within the emerging Thanet Local Plan). The County Council also notes that committed / delivered road improvements incorrectly include the proposed one-way flow from B2050 Park Lane to A28 Canterbury Road. This is not a committed scheme; however, does still form part of the wider plans across the Local Plan period. The delivery of this mitigation is likely to be heavily dependent on the

		delivery of the other new road links in and around the locality of Birchington (such as the A28 to Acol Hill road link). The route analysis and traffic distribution for the sensitivity test included in Section 10, APP-061 is not considered to be reliable, as traffic distribution has been derived using assumptions on the level of traffic redistribution by the applicant's consultancy team, rather than being informed by the dynamic distribution of trips from the KCCSHM. The Highway Authority has appended a copy of the district infrastructure proposal plan to assist the Examiners in understanding how these improvements relate to the Manston Airport site and the strategic housing allocations which form part of the emerging Thanet Local Plan (appendix 3). b) The Transport Assessment for the proposed Thanet Parkway railway station has, to date, reviewed impacts on the highway network for opening year and year 10, which is 2031. No assessment has been carried out on 2039 flows and based on forecast car parking demand the station car park will need to have been extended to prevent a constraint on demand in that timeframe. However, the economic modelling for the station appraises demand over a much longer time period. It is possible for the applicant to commission the economic consultants to provide the spreadsheet model of demand for 2039 and for the transport consultants used on the Thanet Parkway transport assessment to assign that demand on the highway network to ensure a consistent approach. This could then be used in the DCO transport assessment.
Tr.1.18	**Provide a response to the way in which the Applicant has addressed your concerns and considerations as set out in the ES Volume 15 APP-060 Table 3.2 'KCC – January 2018 Section 42 Consultation Response'.** **NOTE**: This question may be responded to through a SoCG or a LIR.	Following the submission of the DCO, the applicant and the Local Highway Authority have been in regular dialogue in order to seek common ground in relation to matters surrounding trip methodology (which, given the relatively bespoke nature of the proposed development, would require a first principles approach to highway trip rate assessment). Following a process of extended dialogue, a mutually agreed trip methodology has now been agreed in principle and this had led to some changes to the traffic assumptions that currently underpin the Transport Assessment within Volume 15 of the ES. The agreed revisions to the trip methodology have informed the recently completed

		strategic modelling exercise using the KCCSHM (as outlined in Question Tr.1.5). However, to date, none this information has been formally submitted by the applicant as formal evidence/submissions to the examination, so at this time these issues remain unresolved. The issue pertaining to the absence of provision for a new highway route to and from Westwood (Haine Road) through the Northern Grass is still unresolved, however since the submission of the DCO, some positive steps have been progressed by the applicant to seek to allay concerns raised by KCC. In line with proposed policy as set out within the emerging Thanet Local Plan (Strategic Routes Policy SP47) and the Thanet Transport Strategy, it is expected that any development within the Northern Grass actively aligns with the strategy by delivering on site road/footway/cycleway infrastructure to accommodate part of a proposed, link road between the A256 and the B2050 (including an appropriate form of junction onto the B2050). This would enable the Inner Circuit Route Improvement Strategy to be delivered in an economical way, by enabling large sections to be built out within the internal layout of development sites, rather than incurring avoidable unnecessary costs related to offsite works. This is likely to be the case on several Strategic Allocation sites within the emerging Thanet Local Plan such as Birchington, Westgate, Westwood (Nash Road and Manston Court Road). The applicant has expressed their requirement for the proposed road link to be realigned, to avoid the need for it delivered through the centre of the Northern Grass and as such, the current masterplan for the site does not propose to facilitate the continued development of this important highway route, which in turn could lead to a significant increase in the amount of off-site works required to deliver infrastructure and increased costs. The County Council, as Highway Authority, has requested a statement of justification/reasoning for this position (given that the indication from the applicant is that the Northern Grass is not intended to form part of airside development), however this has yet to be provided. In the absence of clear and compelling justification, the Highway Authority is of the opinion that the original alignment of the Manston Road to Haine Road link should be included as part of any internal masterplan for the Northern Grass and an

		agreed route corridor secured as part of any development proposal for this site. This will also facilitate delivery of infrastructure by the Highway Authority, should external funding for this infrastructure be obtained/awarded ahead of any built development within the site being delivered. It is relevant to note that the current owners of the site have previously expressed a willingness enter into necessary agreements with the Highway Authority to secure a route across the Northern Grass in accordance with current feasibility designs that have been produced by the Highway Authority. Notwithstanding the above position in relation to the lack of clear and compelling justification from the applicant for precluding delivery of a route through the Northern Grass, the Highway Authority has entered into initial dialogue with the applicant to explore the possibility of an alternative alignment for the Northern Grass section of the Manston Road to Haine Road link, should the DCO be approved without the requirement for on site delivery. Initial design process has suggested that this route would largely avoid the majority of the Northern Grass and utilise the existing Manston Road corridor to the west of the site (with appropriate improvements to the geometry and carriageway/footway construction of this route). To date, this process has yet to be fully concluded to the satisfaction of the Highway Authority. Moreover, it is currently unknown what impact an alternative route will have on scheme cost and third-party land requirements. No further progress has been made in relation to the proposed Signal Junction arrangement at Spitfire Way/Manston Road. The Highway Authority is still of the opinion that a roundabout junction would be the most appropriate solution, as it would maintain route consistency and better serve the future needs of the road network in relation to the proposed Inner Circuit Route Improvement Strategy, which forms part of the Thanet Transport Strategy. In line with the current process of considering an alternative alignment for the Manston to Haine Link, the Highway Authority has requested that the applicant consider the provision of a roundabout option for the Spitfire Way/Manston Road junction, however KCC has yet to receive a design or proposal from the applicant to assess.

		To the knowledge of the Highway Authority, Stage 1 Safety Audits requested have yet to be completed for any of the road improvements. These are essential to ensure that all safety implications from these schemes have been fully considered prior to approval. It has been agreed that the entire route between Spitfire way and the Airport Site access on Manston Road will be widened to 7.3 metres to accommodate HGV Access. KCC still requires details of any emergency access points onto the existing highway network.
Tr.1.20	The ES Volume 15 [APP-060] APP 60 Para 3.4.4 details discussions on the proposed Thanet Park Way Station. **i. What is the current status of the project?** **ii. Is any progress on this anticipated during the course of this Examination?**	The proposed Thanet Parkway station is currently being progressed through outline design by Network Rail. This phase of design is expected to complete in June 2019. The high level programme for the project proposes an opening date of December 2021 (to coincide with the railway timetable change). A planning application for the proposal has been submitted and amendments are currently being made to satisfy the planning comments received. Paragraph 3.4.4 states that the proposed Thanet Parkway station has not been considered in the Surface Access Strategy, due to the lack of commitment to funding the station. This is appropriate at this stage in the station project's development. However, the project remains a high priority for KCC and Thanet District Council and it is part of the mitigation for the submitted Thanet Local Plan. It is also supported by the South East Local Enterprise Partnership (SELEP), who has provisionally committed £10m of funding. However, there remains a funding gap and this must be closed before the detailed design and construction phases can commence. KCC expects this to be resolved during the course of the examination, with the project seeking to approve the £10m funding from SELEP at the Accountability Board meeting in April 2019. Once the station's delivery is confirmed, KCC would expect the Surface Access Strategy to reflect the new station as a more suitable location for rail access than Ramsgate Station. One element of the Thanet Parkway station project is an upgrade to the Cliffsend level

		crossing. KCC notes that Network Rail asked the applicant about their impact on the same level crossing in terms of traffic flows because that might necessitate an upgrade independently of the Thanet Parkway proposal. Network Rail should confirm its satisfaction with the transport modelling from the applicant demonstrating no impact. If, conversely, it is found that there is an impact then KCC would work with the applicant to jointly upgrade the level crossing.
Tr.1.22	The ES Volume 15, Part 2 [APP-061] para 7.2.1 notes two future year scenarios that have been used in carrying out traffic impact assessments: 2039 Baseline with background traffic growth; and 2039 Baseline with Proposed Development traffic. **State whether a more logical formulation should include 2039 Baseline with both background traffic growth and Proposed Development traffic.**	KCC is of the opinion that two future year scenarios should be developed. 2039 Baseline – this should include all growth and highway infrastructure earmarked within the emerging Thanet Local Plan (as outlined within the existing KCCSHM) plus TEMPRO growth factors between 2031 and 2039 (to encompass growth that has yet to be specifically planned for between this period). 2039 Do Something - the identified 2039 baseline (as above) + proposed DCO development traffic. This scope has been agreed with the applicant in relation to the most recent modelling that has been undertaken. However, the way in which the baseline and future traffic growth has been derived within the current TA is not agreed by the Local Highway Authority. Please note that the Highway Authority considers that as the proposed development subject to the DCO will build out over the period of the submitted Thanet Local Plan, it should proportionately contribute towards infrastructure requirements within the Thanet Transport Strategy, either through physical improvements or appropriate financial contributions. The Highway Authority considers that the emphasis for funding the necessary changes to infrastructure apportionment should be borne by the applicant.
Tr.1.26	**In respect of In the ES Volume 15, Part 2 [APP-061] Section 7, is KCC content with the lack of mitigation measures proposed for junction 8 as set out in Para 7.11.7?**	The Highway Authority disagrees with the lack of mitigation at this junction within the framework of the traffic distribution suggested within the TA; however, as outlined above, the assumptions made regarding growth factors to 2039 and traffic distribution are likely to provide an unreliable picture of future traffic conditions in the locality.

		The conventional modelling methods that have been used within the TA are unreliable, due to the unique geometrical arrangement of this junction. The junction is not a 'left in/left out' arrangement as suggested (no turning movements are currently prohibited) and Park Lane is subject to a single way working system close to its junction with A28, which further reduces capacity beyond that suggested within the model. It is considered that any modelling outputs should be treated with caution, as it is unlikely that a conventional junction model will be able to accurately replicate the interaction between the single way working section, signalised pedestrian crossing on A28 close to the junction and any queueing back from the Mini Roundabout and right turn movements at A28 to park Lane which leads to blocking back of traffic on both the A28 Northbound (referred to as Junction 8a) and Park Lane. On site observations suggest that the baseline model significantly underestimates the existing traffic queuing that occurs within this locality, particularly on the northbound approach to the Park Lane junction. As such, this casts doubt over the validity of future model forecasts.
Tr.1.27	In the ES Volume 15, Part 2 [APP-061] Table 7.56 shows that junction 16 is currently working above capacity. Para 7.18.7 indicates that this will still be the case following mitigation and using Year 2039 plus development traffic figures. **Is this acceptable to KCC?**	Whilst the Highway Authority would not usually seek mitigation above network baseline conditions, it disagrees with the form of mitigation at this junction. As outlined above, the assumptions made regarding growth factors to 2039 and traffic distribution are likely to provide an unreliable picture of future traffic conditions in the locality. As such this junction should be reviewed considering more recently identified modelling through the KCCSHM. The proposed scheme of mitigation for the Ramsgate Road/College Road/A254/Beatrice Road junction would appear to result in a highly unconventional junction layout, which is unlikely to be acceptable to the Highway Authority, not least due to the lack of inter-visibility between the stop lines. Again, an independent Stage 1 Road Safety Audit will need to be submitted as part of any further justification for this scheme for an informed position to be identified.
Tr.1.28	In the ES Volume 15, Part 2 [APP-061] Table 7.96 shows that junction 27 is currently working	Whilst the Highway Authority would not usually seek to secure mitigation above network baseline conditions, as outlined above, the assumptions made regarding growth factors to

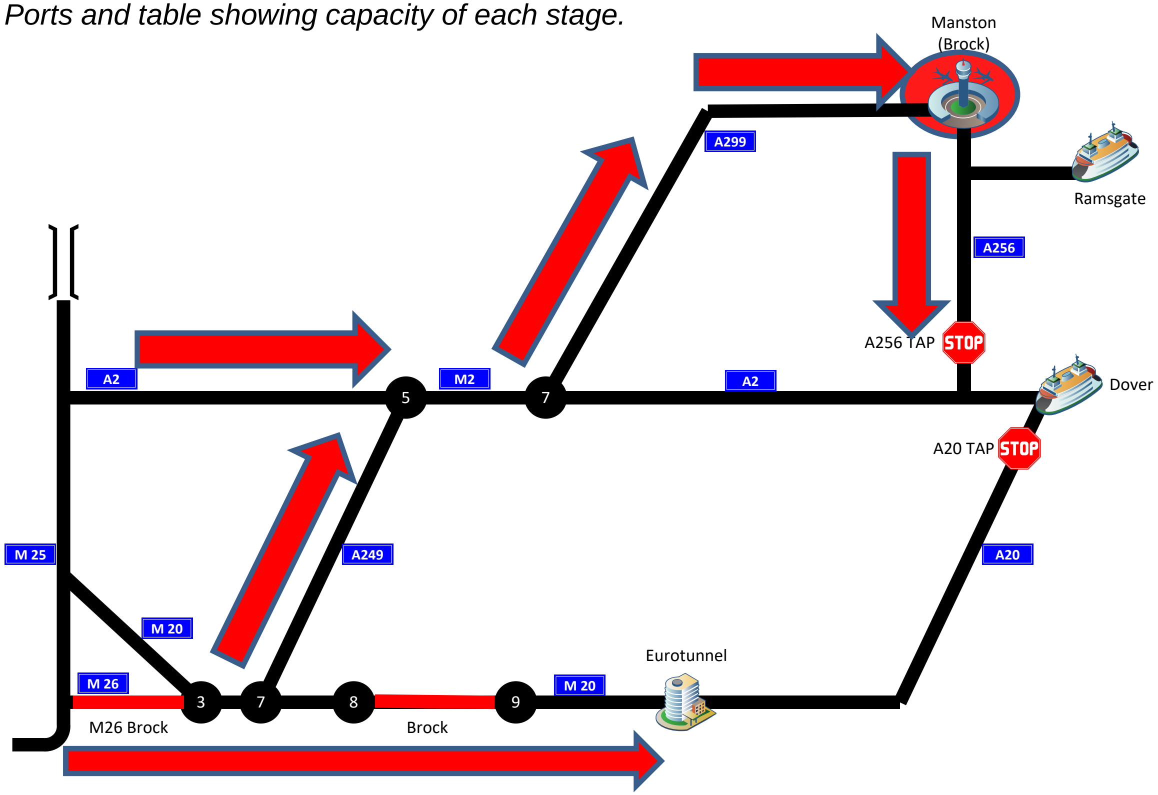
	above capacity. Para 7.28.6 indicates that this will still be the case following mitigation and using Year 2039 plus development traffic figures. **Is this acceptable to KCC?**	2039 and traffic distribution are likely to provide an unreliable picture of future traffic conditions in this locality. Notwithstanding the above, it is evident that there would be significant vehicle/queue interaction between the B2014 Newington Road/Manston Road junction and the adjacent A255/B2014 Newington Road roundabout in the PM peak following the implementation of the proposed scheme of mitigation, with enhanced queue lengths on the B2014 (south) arm arising from the proposed development. This is not considered to be acceptable and should be addressed, with the two junctions assessed within a network model.
Tr.1.29	**In respect of In the ES Volume 15, Part 2 [APP-061] Section 7**, **is KCC content with the lack of mitigation measures proposed for junction 28 as set out in paragraph 7.29.4?**	As outlined above, the assumptions made regarding growth factors to 2039 and traffic distribution are likely to provide an unreliable picture of future traffic conditions in this locality. Notwithstanding this, at face value, the impacts pertaining to this junction are likely to be modest. The Highway Authority would like to reserve its position regarding this junction until further modelling has been completed using the outputs from the KCCSHM.
Tr.1.31	In the ES Volume 15, Part 2 [APP-061] para 7.30.14 sets out the timing and other arrangements for installing mitigation measures at road junctions. **Is KCC content with these arrangements?**	KCC as the Highway Authority does not agree with the conclusions stated within this section. The site and junction-specific, rather than strategic approach to capacity assessment taken in the TA, is inappropriate, resulting in highway mitigation proposals that deliver only partial benefits, and which do not align with or incorporate the robust, long-term solutions proposed by the Thanet Transport Strategy. The County Council suggests that further dialogue will be needed with the applicant to agree a more strategic approach to mitigation across the local highway network in line with the Thanet Transport Strategy, once modelling assessment outputs have been completed and submitted for consideration. Notwithstanding the above, the Transport Assessment appears to set out no defined trigger points for the proposed mitigation strategy, which is not considered by provide adequate clarification or safeguarding over the proposed delivery timescales of any of the mitigation or works.

Tr.1.33	In the ES Volume 15, Part 2 [APP-061] para 7.31.2 refers to works to be undertaken at three junctions in order to improve road safety and notes that two of these are also to be improved on grounds of capacity. **Does the Applicant, with KCC, intend to give priority to the works which will improve road safety?**	KCC agrees that priority should be afforded to schemes that are identified as having highway safety concerns. The timetable for implementation of the proposed highway improvement schemes has yet to be clarified by the applicant, however they should be provided at the earliest possible juncture. Further clarification is required with respect to this matter. The County Council would like to reiterate that Stage 1 Safety Audits are required for all material highway alterations before an informed assessment of them can be made.
Tr.1.36	In the ES Volume 15, Part 2 [APP-061] Section 10 deals with sensitivity testing for possible changes resulting from the adoption of the TDC local plan. The potential for changes to the measures proposed for improvement and mitigation to alter as a result of this sensitivity testing is identified. **At what stage, if at all, will these changes be made?**	The route analysis and traffic distribution for the sensitivity test included in ES Volume 15, Part 2 [APP-061] Section 10 is not considered to be reliable, as traffic distribution has been derived using assumptions on the level of traffic redistribution by the applicant's consultancy team, rather than being informed by the KCCSHM. As outlined in response Tr.1.13, there are two key highway links missing from the list of proposed interventions. The delivery of the infrastructure outlined within the Thanet Local Plan is expected to be delivered in line with the delivery of strategic allocation sites. It is expected that the Inner Circuit Route Improvement Strategy will be delivered in sections with funding /delivery requirements being apportioned in an efficient way to enable strategic housing sites to be delivered in line with growth requirements. KCC considers that development on the Manston Airport Site should proportionately contribute towards the development of the Inner Circuit Route Improvement Strategy, in line with other strategic allocation sites within the emerging Local Plan.
Tr.1.37	The ES Volume 15, Part 2 [APP-061] contains Appendices A to D of the ES, with Appendix A giving consultation meeting notes. This question relates to information included in this Appendix. Various points were raised by KCC in a letter to the Applicant dated 21 September 2017 about a	**Letter dated 21st September 2017 (appendix 2)** KCC can confirm its latest position of the in relation to matters raised in this correspondence are as follows:- The concern relating to HGV movements is partly addressed through conformation that Spitfire Way and Manston Road will be widened, however conformation is still required in

	scoping document of July 2017. **Have all the issues raised been resolved to the satisfaction of KCC?** In a letter dated 16 February 2018 KCC provided a response to the Applicant's second statutory consultation. In this reference was made to a letter of 21 July 2017 containing the KCC response to the first consultation and indicating that the information in both responses should be considered together. The second letter, of 21 July 2017, is not included in the bundle and should be produced. **Have all the issues raised in it been resolved to the satisfaction of KCC?** The KCC responses to the traffic and transport issues raised in the PEIR are included as Appendix 2 to the letter of 16 February 2018. **Have all the issues raised in it been resolved to the satisfaction of KCC?**	relation to how and when these improvements will be delivered. 3.1 Trip Rates and 3.5 Trip Distribution. The trip profile included within the current TA submission still contains several discrepancies and areas requiring further clarification. These are outlined in the KCC LIR. Since the submission of the DCO additional dialogue has been held with the applicant as outlined in answers Tr.5, Tr.1.18 and Tr.1.18. 4&5 Future year/Traffic Impact. This issue has yet to be formally addressed to the satisfaction of the Highway Authority. However, more recent strategic highway modelling has been undertaken and it is expected that the applicant will be producing a supplementary Transport Assessment/Addendum to in due course, as outlined in answers Tr.5, Tr.1.18 and Tr.1.18. To the knowledge of the Highway Authority, no specific agreed position has been reached between the applicant and Thanet District Council in relation to potential impacts from development on local housing needs/projections, which in turn may have a bearing on any future traffic projections. **The KCC responses to the traffic and transport issues raised in the PEIR** KCC can confirm its latest position of the in relation to matters raised in this correspondence are as follows: - Traffic generation and distribution methodology. The current position of the Highway Authority is set out in the KCC LIR. However, it is relevant to note that to the knowledge of KCC, the applicant has yet to propose a cap on freight that the airport will be permitted to handle in line with assumptions made within the Trip Rate methodology. MasterPlan - the concerns relating to the A256 Haine Road to B2050 Manston Road link have yet to be resolved. This is outlined in answer Tr.1.18. This extends to the concerns over the lack of appropriate links to Westwood (by all modes of transport). All other points raised within this answer are addressed within the LIR and/or replicated in

		previous questions.
Tr.1.39	**What effect will the application have on the implementation of measures under Operations Stack and Brock (or any later iterations)?**	As the statutory Highways Authority, KCC is responsible for maintaining all roads within its administrative boundary, except the motorways and major (trunk) roads which are managed by Highways England. KCC works in a multi-agency group with Kent Police, Eurotunnel, the Port of Dover, Highways England, the Department for Transport (DfT) and other authorities to manage freight traffic through Kent. This is called Operation Fennel, which includes, among others, Operation Stack on the M20. Manston Airport has also been part of Operation Fennel since 2015 and now forms part of the contingency plans in place in case of a 'No-Deal' Brexit - Operation Brock. The contingency plans are part of a four-stage process of queueing HGVs, whilst keeping the M20 open in both directions for all traffic. These stages are outlined below: **Stage 1** – the use of port buffer zones within the Port of Dover and Eurotunnel to queue freight. Once these are full, Dover Traffic Access Protocol (TAP) will be used to queue HGVs on the inside lane of the A20 between Dover and Folkestone on the approach to Dover. **Stage 2** – once the A20 TAP is reaching capacity, Eurotunnel and Port of Dover freight will be held between junctions 8 and 9 of the coastbound M20 with a traffic light system to release vehicles to the ports (Brock M20). A contraflow system on the London-bound carriageway between junctions 9 and 8 will allow dual two lane flow in both directions for all other (non-port) traffic. **Stage 3** – once Stage 2 starts to reach capacity, freight traffic will be split at M20 junction 7 – Eurotunnel freight will continue to be stored in Brock M20 and Port of Dover freight will be diverted to Manston via the A249 (from M20 junction 7), along the M2 and A299. Freight vehicles will then be released to the Port of Dover via the A256 and held in a TAP queue at the end of the A256 before being released via the A2 to the Port of Dover. **Stage 4** – if Eurotunnel freight capacity is greater than Stage 2 on the M20 junctions 8 to 9, then the M26 would be used to hold additional Eurotunnel freight, with Port of Dover freight using the A2/M2 before heading to Manston. **Stage 5** – if all the above stages reach capacity, the DfT National Freight Plan should define where freight could be held outside Kent.

Kent County Council's Response

		These preparations should ensure that all main corridor routes through Kent are kept moving, including the M20, which will continue to provide access to Port of Dover for prioritised freight, passenger traffic and any additional flow to ensure that the Port of Dover operates at available capacity. KCC's position remains that use of the M26 as Stage 4 of the traffic management plans should not be instigated unless absolutely necessary, as a last resort. The four-stage process is explained in the **Figure 1** below: **Figure 1** – *Diagram explaining the process of queuing HGVs on approach to the Channel Ports and table showing capacity of each stage.* 

BROCK STAGE	**1**	**2**	**3**	**4**	**5**
Includes	Use of Port of Dover and Eurotunnel Buffer Zones Use of A20 TAP	M20 Junction 8-9 contraflow	Dover traffic to Manston Dover A256 TAP	M26 (last resort) Concerns remain that the implementation model with Highways remains unclear and untested	Hold freight outside of Kent
Freight capacity	Buffer Zones – 1200 A20 TAP - 500	M20 8-9 - 2000	Manston – 5000-6000 A256 TAP – 300-800	M26 - 2000	

In January 2019, the DfT, supported by KCC, arranged a trial in which 89 HGVs were used to test the operation of Manston Airport in an Operation Brock scenario. The trial tested the entry arrangements into Manston, the outflow of HGVs from Manston and trialled the traffic management system of the A256 TAP on approach to Whitfield. The trial was extremely successful and has shown how Manston can best be used to store HGVs. KCC and the DfT are therefore confident that Manston will be sufficient should it need to be used for queuing HGVs.

<u>Effect of the DCO on Op Brock/Stack Plans</u>

The DfT has agreed with the existing land owner, Stone Hill Park, that Manston Airport can

		be reserved for the use of queueing port-bound HGVs until December 31st, 2020. As part of the DCO application, River Oak Strategic Partners is proposing to start construction works in Q3 2019 and to have a proposed opening year of Q4 2020**. KCC would like clarification on these timescales and how they may affect the current agreement with the DfT as its use as a contingency for queueing port bound freight vehicles.** Should the DCO be granted, any negotiations as to the extension of the use of Manston to stack HGVs would have to be made between the DfT and the future landowner. Currently, there are still uncertainties as to how long, if at all, Manston will have to be used, so it is difficult to comment regarding the future at this stage. **KCC is, however, concerned that should Manston become unavailable for stacking HGVs, other less favourable contingency plans would have to be enabled, such as the use of the M26 to queue HGVs. This could cause considerably greater disruption across Kent and the South East than the use of Manston.**
Tr.1.40	**PRoW** Para 2.3.5 of the 'Public Rights of Way Management Strategy' (Appendix M in the Environmental Statement Volume 25: Transport Assessment, Appendices J (Junction 21B) – O 3/3 [APP-073]) cites a chance meeting with a local resident. **Have the Applicant or KCC carried out any other more evidenced studies of current usage of the sections of the potentially affected PRoWs?**	The County Council PRoW & Access team has not completed specific studies of the current usage of the sections of the potentially affected PRoW. However, the County Council is aware that the area is known to be well used for equestrian and recreational use.
Tr.1.42	**PRoW** Paragraph 3.2.1 of the 'Public Rights of Way Management Strategy' (Appendix M in the Environmental Statement Volume 25: Transport	It is proposed that TR8 will be rerouted along the edge of the new proposed perimeter fence of the airport. The previous route would be permanently closed and the new route permanently established.

	Assessment, Appendices J (Junction 21B) – O 3/3 [APP-073]) states that: KCC East Kent Area Officer for PRoW & Access Service has been consulted regarding the Proposed Development. **i. Comment on the proposals as set out in the 'Public Rights of Way Management Strategy'; and** **ii. confirm or otherwise its formal agreement to them.**	KCC would strongly advise the applicant to contact the KCC PRoW and Access Service at their earliest convenience to discuss any required route diversions. The width of the bridleway will be 3 metres and it is proposed to run alongside a hedgerow planted east of the fence to allow for screening of the car park and the Airport site. Any way marking posts or other PRoW infrastructure will be replaced and moved as appropriate. KCC requests that any hedge or vegetation planting required as screening to be at least 2 metres away from the boundary of the bridleway. This will ensure the full width of the bridleway is open and available as the hedge matures and will facilitate future vegetation clearance and hedge maintenance without requiring closure of the bridleway. In respect of ongoing maintenance, it will be expected that site operators take on maintenance responsibilities for any landscaping and enhancements to benefit the PRoW network. In the case of any planted vegetation screening, this should be cut on a regular basis so that PRoW are open and available to their full width at all times. KCC requests that maintenance responsibilities are captured within the DCO. It is proposed that TR9 will be extinguished south of the perimeter fence of the airport so that no PRoW now falls within the redline boundary of the site. The County Council accepts that the part of the bridleway that lies within the site boundary will have to be extinguished and that this is not currently used, as it is a dead end route.
Tr.1.44	**PRoW** Paragraph 3.2.1 of the 'Public Rights of Way Management Strategy' (Appendix M in the Environmental Statement Volume 25: Transport Assessment, Appendices J (Junction 21B) – O 3/3 [APP-073]) states that: "*KCC requested that PRoW are to be created and funded under a Section 106 Agreement and would be maintained by KCC while remaining part of Manston Airport*	The County Council agrees that any agreement made between KCC and the applicant will be made through a Development Consent Obligation under s174 of the 2008 Planning Act, as appropriate. KCC would expect money to be secured to improve the surface of the existing and diverted bridleways to a minimum width of 3m along the entire length. This will include bridleways TR8 and TR10. KCC is happy to supply a cost for this work. There has currently been no progress in developing this agreement.

	land." **i. Confirm or otherwise that any agreement will be made a Development Consent Obligation under s174 of PA2008 of the 2008 Planning Act (PA2008); and** **ii. report on progress in developing this agreement.**	
Tr.1.46	**PRoW** Paragraph 4 of 'Appendix A - Site visit undertaken on 31 of October 2017 - Meeting minutes' in the 'Public Rights of Way Management Strategy' (Appendix M in the Environmental Statement Volume 25: Transport Assessment, Appendices J (Junction 21B) – O 3/3 [APP-073]) states that: "*Currently, PRoW applications take about 2.5 years to be looked at by KCC. That timescale is likely to soon reach 3 years. If, however, the submission is classed as Nationally Significant Project, that timeframe may possibly be shorter*." Table 3.1 of the 'Public Rights of Way Management Strategy' (Appendix M in the Environmental Statement Volume 25: Transport Assessment, Appendices J (Junction 21B) – O 3/3 [APP-073]) states in relation to TR8 that: "*The previous route will be permanently closed and the new route permanently established. This will be done early in the project life cycle so it is established before major works take place*." **i. Comment on the apparent discrepancy between the timelines for the PRoW application and the commitment to undertake this action early in the project life cycle; and**	The County Council notes that the details of the PROWs that may be required to temporarily close or be diverted, with explanation of how this will be carried out, are listed as part of the Development Consent Order. As such, it is understood that there is no requirement for diversions and extinguishments to be completed under s257 of the Town and County Planning Act 1990. It is requested, however, that the County Council is contacted by the applicant to discuss the paths that would be temporarily closed. This would enable the PRoW team to negotiate these closures, to ensure that disruption for the public would be minimised. Therefore, there is no need for the diversions and extinguishments to be completed under s257 of the Town and County Planning Act 1990 and be listed in 'Details of Other Consents…", provided the necessary details are included as part of the DCO.

	ii. Show where the need for this consent is referenced in 'Details of Other Consents and Licences that may be required' [APP-087]	
Tr.1.47	**PRoW** Paragraph 4.1.6 of the 'Public Rights of Way Management Strategy' (Appendix M in the Environmental Statement Volume 25: Transport Assessment, Appendices J (Junction 21B) – O 3/3 [APP-073]) states in connection with a strategy to create a new link between Thanet Parkway Station and TR9 that: *"[The] Creation of a new link around the eastern boundary of the proposed Airport redevelopment will not be progressed. This however could be potentially addressed by a bus service providing a north south link should the planned Thanet Parkway Station go ahead*." **Comment on this proposed decision in relation to any proposals for Thanet Parkway Station.**	The proposal for the Thanet Parkway Station does not include a direct walking and cycling link (or public right of way) to the site of the proposed airport redevelopment. The Public Rights of Way Management Strategy states that a new link from bridleway TR9 to the proposed Thanet Parkway Station across the site or around the edge of the site cannot be provided as part of these development proposal. The reason stated for not providing this route is because the alternative route would be a very long route around the eastern side of the site following the perimeter fence that would potentially make it unattractive to users as it would take a long time to take this circuitous route. However, it does include a new link to Cliffsend via the footpath (reference TR32) with a new connection following the field boundary to Clive Road. In future, if the airport is reopened, KCC would welcome the reconsideration of a new link to the station. The County Council requests that the additional connection to Thanet Parkway is still considered by the applicant, as this will greatly benefit the sites connectivity and will further increase opportunities available to the local community for recreation, active travel and exercise.

[redacted]

New Roads and Street Works Act 1991

HAUC

HIGHWAY AUTHORITIES & UTILITIES COMMITTEE

MEASURES NECESSARY WHERE APPARATUS IS AFFECTED BY MAJOR WORKS (DIVERSIONARY WORKS)

A Code of Practice

Approved by the Secretaries of State for Transport, Wales and Scotland under sections 84 and 143 of the Act

THE DEPARTMENT OF TRANSPORT

Y Swyddfa Gymreig
The Welsh Office

THE SCOTTISH OFFICE

June 1992

6 REDUNDANT HIGHWAYS*

6.1 Formal closure (Stopping Up)

The term 'redundant highway*' applies to a section of highway* which the highway authority* or Secretary of State wish to close under their formal legal powers, which are described in Appendix D. In effect this means that the land, including layby, verge or footway, is no longer required for any highway* purpose. Historically most highways* were constructed over private land, the highway authority only having the right to provide and maintain the surface. Hence if a highway* is closed, (and in Scotland it is no longer used as a road) the rights of passage are extinguished and the land ownership normally reverts to the original owners, usually considered to be the frontagers.

The highway authority* would normally seek a stopping up order when they wish to remove the right of public access to the land and hence remove their own duties with regard to maintenance and public liability. The closing of the redundant highway* would enable it to be physically separated from the adjacent public highway*, avoiding unauthorised activities such as fly tipping or encampments, and bringing about a significant environmental improvement.

When a highway* which is to be the subject of a stopping up order contains undertakers' apparatus, the highway authority* should be aware of the undertaker's need for adequate access or protection, and should discuss the intended closure with him at an early stage. In the interest of achieving the least cost solution, the general presumption should be that the apparatus will remain in position where there is no need to disturb it, even though there may be some detriment to the owner.

The rights of undertakers are protected under the various stopping up orders as explained in Appendix D. The highway authority* should inform undertakers of the proposed stopping up and the undertakers should then ensure that the highway authority* are aware of his requirements so that provisions can be made either in the stopping up order or by agreement. If an undertaker's rights are adequately protected, and the route continues to be suitable, he will not be expected to object to the stopping up order. The undertaker should also consider the provision of ducts in the new or improved section of highway* to facilitate a future diversion. If the highway authority* installs ducts as part of its works then ducts should be free-issued by the undertaker.

Highways* may also be closed to facilitate development. In this case it would be normal for the developer to negotiate with the undertaker and the highway authority* for a diversion or a wayleave or easement.

6.2 Change of Use

In addition to redundant highways* there are instances where parts of a highway* become surplus to their original purpose (i.e. as a carriageway or footway or verge) but as the result of improvement could now be used as a layby, for example. If no formal stopping up order is made, then this surplus land still retains the legal status of a highway* and undertakers' rights are protected.

Where a highway authority* wish to use part of the original highway* (e.g. a layby) for the temporary storage of materials, care should be taken to avoid obstruction of access to any undertakers' apparatus which is present. It should also be noted that salt stockpiles can contaminate the ground and accelerate the corrosion of certain apparatus.

APPENDIX D

STOPPING UP AND DIVERSION ORDERS

This Appendix briefly summarises the main powers under which stopping up and diversion orders may be made and the protection provided for the rights of undertakers in such cases. It does not purport to set out the full legal position.

ENGLAND AND WALES

Type of Highway	Powers	Order Making Authority
1. Roads affected by the construction/improvement of a trunk road (or special road provided by the Secretary of State)	Highways Act 1980, sections 14 and 18	Secretary of State
2. Roads affected by the construction/improvement of a classified road (or special road provided by the local authority)	Highways Act 1980, sections 14 and 18	Local highway authority (Confirmation by Secretary of State)
3. Roads (other than trunk or special roads) no longer necessary (or diverted to become more commodious to the public)	Highways Act 1980, section 116	Magistrate's Court
4. Highways affected by development	Town and Country Planning Act 1990, section 247	Secretary of State
5. Highways crossing or entering the route of a proposed new highway	Town and Country Planning Act 1990, section 248	Secretary of State

UNDERTAKERS OTHER THAN TELECOMMUNICATIONS OPERATORS

Under sections 14 and 18, Highways Act 1980

Undertakers' rights to retain apparatus in the old highway may be extinguished unless provision is specifically included in the order to protect such rights. Sections 21 and 22 apply the code set out in sections 271 to 282 of the Town and Country Planning Act 1990 which enables the highway authority to require the undertaker to move his apparatus, but obliges them to pay the undertaker's costs (section 279). The Town and Country Planning Act code also allows the undertaker to require that his apparatus be moved, again at the expense of the highway authority; provision exists for the highway authority to serve a counter-notice.

Under section 116 (and Schedule 12), Highways Act 1980

Undertakers retain the same powers and rights in respect of their apparatus in the highway as though the stopping up order had not been made. Schedule 12, Part III, paragraph 5, of the 1980 Act provides for the apparatus to be moved at the option of the undertaker or at the reasonable request of the highway authority and the highway authority must pay the cost of essential works.

Under sections 247 and 248, Town and Country Planning Act 1990

Undertakers lose their powers to retain apparatus in the old highway unless provision is made under section 247(4)(b) to preserve those rights. The Secretary of State can make such provision as appears to him to be necessary or expedient under section 247(2). If undertakers' rights are extinguished under the code, the relevant authority must pay the undertakers' costs.

TELECOMMUNICATIONS OPERATORS

Under sections 14 and 18, Highways Act 1980

The protection provided by section 334 of the Highways Act 1980 as amended applies. In essence the operator retains the same power in respect of the apparatus as if the order under sections 14 and 18 had not been made.

Under section 116, Highways Act 1980

The protection provided in section 334 of the Highways Act 1980 as amended by the Telecommunications Act 1984, Schedule 4, paragraph 76(4), applies. In essence the highway authority must serve notice of the granting of the stopping up order on the operator. The operator has 3 months to serve a counter-notice requiring the highway authority to pay for the removal of apparatus affected by the order.

Under sections 247, 248 and 249, Town and Country Planning Act 1990

The protection provided by section 256 of the Town and Country Planning Act 1990 applies. In essence, the operator retains the same powers in respect of the apparatus as if the order under section 248 had not been made.

SCOTLAND

Type of Roads	Powers	Order Making Authority
1. Roads affected by the construction/improvement of special roads	Roads (Scotland) Act 1984, section 9	Secretary of State for Scotland, or local roads authority confirmed by Secretary of State
2. Roads affected by the construction/improvement of public roads other than special roads under section 9(1)(c) of the Roads (Scotland) Act 1984	Roads (Scotland) Act 1984, section 12	Secretary of State for Scotland, or local roads authority (confirmed by Secretary of State where objections are not withdrawn)
3. Roads (other than those where section 12 or section 9(1)(c) of the Roads (Scotland) Act 1984 would apply) which have become dangerous, or unnecessary	Roads (Scotland) Act 1984, section 68	Secretary of State for Scotland, or local roads authority (confirmed by Secretary of State where objections are not withdrawn)
4. Roads affected by development	Town and Country Planning (Scotland) Act 1972, section 198	Secretary of State for Scotland

5. Roads other than trunk or special roads affected by development	Town and Country Planning (Scotland) Act 1972, section 198A and section 206	Local Planning Authority confirmed by Secretary of State for Scotland in accordance with section 206 where the order is opposed
6. Footpaths and bridleways affected by development	Town and Country Planning (Scotland) Act 1972, section 199	Local Planning Authority (confirmed by Secretary of State for Scotland where the order is opposed)

UNDERTAKERS OTHER THAN TELECOMMUNICATIONS OPERATORS

Under section 9 of the Roads (Scotland) Act 1984

A roads authority may remove an undertaker's apparatus from land acquired or appropriated by them in pursuance of a special road scheme. Section 134 of the Roads (Scotland) Act applies the provisions of sections 219 and 220 and 222 - 225 of the Town and Country Planning (Scotland) Act 1972. This sets out the procedures for a roads authority to serve notice of the extinguishment of the right to place and renew apparatus, and the procedure for a statutory undertaker to serve a counter-notice.

Under sections 12 and 68 of the Roads (Scotland) Act 1984

Orders under these sections must include provision for the preservation of statutory undertakers' rights in respect of apparatus in the road at the time the order is made.

Under sections 198, 198A and 199, Town and Country Planning (Scotland) Act 1972

Orders made under these sections may include provision for the preservation of any rights of statutory undertakers in respect of apparatus in the road at the time the order is made.

TELECOMMUNICATIONS OPERATORS

Under sections 9, 12 and 68 of the Roads (Scotland) Act 1984

The protection provided by section 132 of the Roads (Scotland) Act 1984 applies. In essence the operator retains the same power in respect of the apparatus as if the stopping up order had not come into force, but any person entitled to land over which the road subsisted might require the alteration of the apparatus.

Under sections 198, 198A and 199 of the Town and Country Planning (Scotland) Act 1972

Section 209 (provision as to telegraphic lines) of the Town and Country Planning (Scotland) Act 1972 is amended by Schedule 4, paragraph 54, of the Telecommunications Act 1984. Essentially for orders under sections 198 and 198A the operator retains the same power in respect of any telecommunications apparatus as if the stopping up order had not become operative, but any person entitled to land over which the road subsists, and any local roads authority is entitled to require the alteration of the apparatus. For orders under section 199 the planning authority must give notice of the making of the order. Thereafter the operator must remove or give notice of their intention of removing apparatus within 3 months of the date of the order stopping up the bridleway or footway, or else the apparatus will be deemed to have been abandoned. The operator is entitled to recover certain expenses from the planning authority.

Growth, Environment & Transport

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Ref: GT/BC/JAC
Date: 21 July 2017

Mr. G Yerrall
Director
RiverOak Strategic Partners Limited
Audley House
9 North Audley Street
Mayfair
London W1K 6WF

BY EMAIL ONLY

Dear George

Re: Manston Airport - Consultation
Section 42 Planning Act 2008

Thank you for your letter dated 09 June 2017 consulting Kent County Council (KCC) on the proposal led by RiverOak Strategic Partners to reopen Manston Airport, under Section 42 of the Planning Act 2008.

Officers of the County Council have reviewed the Preliminary Environmental Information Report (PEIR) and welcome the opportunity to comment on a number of environmental and technical matters. For ease of reference, the comments are structured under the chapter headings used in the PEIR.

Approach to the PEIR (Chapter 5):

KCC has statutory responsibilities for improving the health of its citizens and providing local public health services. These responsibilities are set out in the Health and Social Care Act 2012. The County Council has noted the view of the Secretary of State that the need for a Health Impact Assessment is a matter for the discretion of RiverOak Strategic Partners. However, the Secretary of State also advised (para. 5.8.1 pg. 5-12):

> *"… the Applicant should have regard to the responses received from the relevant consultees regarding health…"*

The County Council would expect RiverOak Strategic Partners to conduct a participatory Health Impact Assessment with local communities to ensure that the proposal maximises all possible opportunities to enhance the positive health impacts on the local communities and reduce the negative health impacts.

The Thanet District is one of the most deprived areas of Kent and subsequently experiences some of the worst health outcomes and lowest life expectancy rates of all populations in Kent. Analysis produced by the KCC Public Health Observatory shows that 24 of the 88 most deprived local population clusters (Lower Layer Super Output areas) lie within the Thanet District.

Detrimental impacts of both noise (addressed in greater detail under Chapter 12) and air pollution are therefore likely to have a greater attributable impact on these populations, and particularly for those people living closest to the Manston Airport site or impacted directly under the flight paths. These communities are most likely to be:

- Newington (Thanet 013A and Thanet 013B); and
- Ramsgate (Thanet 016C and Thanet 016A).

All of these communities have high rates of premature mortality, emergency admission rates and rates of disability, and higher than expected rates of diagnosed mental health conditions.

The Newington community has a high proportion of social housing and very high numbers of children, and is potentially most likely to experience the greatest impacts from flight noise and particularly night flights. There is robust evidence which demonstrates the impact that noise has on health, and particularly sleep patterns. Vulnerable groups (e.g. children, the chronically ill and elderly) are more susceptible and thus larger proportions in the aforementioned areas are likely to be more affected.

Air Quality (Chapter 6)

For the avoidance of doubt, the following comments are made in the context of the statutory public health responsibilities KCC possesses which are set out under the Health and Social Care Act 2012.

It is widely recognised that air pollution has a major attributable impact on the health of the population. Given the local vulnerabilities, it is likely to have a greater attributable impact on populations closest to the Manston Airport site. The County Council would expect any operator - in conjunction with the Thanet District Council Environmental Health team - to ensure that it has suitable air quality monitors in place to continually measure local air quality and be taking real time remedial actions in order to reduce such impacts. KCC would expect any operator to comply with all UK air quality guidance and additionally, have regard to the NICE (NG70) *Air pollution: outdoor air quality and health guidance* [1] in planning and operational matters, as appropriate.

[1] June 2017 *Air pollution: outdoor air quality and health* NICE guideline [NG70]

Biodiversity (Chapter 7):

KCC is satisfied that its previous comments[2] made in response to the Scoping Report have been addressed. The Biodiversity chapter is considered to be thorough and provides a wide overview of the potential ecological impacts.

The County Council considers that further surveys are required to adequately establish the potential impacts that may arise through potential increases in air pollution. This is recognised within the report where it is stated that additional air quality modelling and traffic assessments will be undertaken and therefore KCC is satisfied that the matter will be addressed. In addition, the County Council expects thorough assessments in relation to any potential noise impacts when undertaking the noise impact assessments. Consequently, all the conclusions should be re-addressed within the submission of the Environmental Statement.

KCC agrees that appropriate mitigation measures can be implemented to ensure that there will not be a likely significant impact upon great crested newts, bats, and reptiles. It is expected that the Environmental Statement will include all necessary mitigation measures, including where protected species impacts are expected as well as where the impacts will not be significant. The County Council expects that the Environmental Statement will be in accordance with the 'mitigation hierarchy', ensuring that where the potential for ecological impacts to occur is identified, the approach to development will first try to avoid the impacts, then minimise impacts and, as a last resort, compensate for any remaining ecological impacts.

KCC welcomes the proposals for off-site restoration and enhancement works in relation to any potential impacts that the proposed development may have and where on-site mitigation is not possible. It is expected that full mitigation measures are included in the submitted Environmental Statement to demonstrate that any off site mitigation is fully achievable.

Freshwater environment (Chapter 8):

Table 8.1 (pg. 8-1) indicates that a Hydrogeological Risk Assessment, Flood Risk Assessment and Drainage Strategy will all be produced to inform the forthcoming Environment Statement. KCC, as Lead Local Flood Authority, therefore has no detailed comments to make at this stage. However, the Authority would welcome the opportunity to engage with the applicant's consultants at the earliest possible stage of their preparatory works to ensure that its requirements and recommendations are fully incorporated into the final Drainage Strategy.

Historic Environment (Chapter 9)

KCC Heritage Conservation has previously commented on the Scoping Report[3] and has a number of comments to make on the Historic Environment chapter. For ease of reference, these are set out in an appendix accompanying this letter.

[2] Set out in my letter dated 28 July 2016 to the Planning Inspectorate.
[3] Set out in my letter dated 28 July 2016 to the Planning Inspectorate.

Land Quality (Chapter 10):

The application site does not lie within a Mineral Safeguarding Area as defined by the Kent Minerals and Waste Local Plan 2013-30 Policies Maps. Therefore KCC, as Minerals and Waste Planning Authority, does not consider there to be any associated Mineral Safeguarding issues.

Noise (Chapter 12):

For the avoidance of doubt, the following comments only relate to noise from aircraft operations. Construction traffic and ground noise will be of greater relevance to Thanet District Council's Environmental Health team.

Aircraft noise, as the PEIR correctly identifies, is not a statutory nuisance. However, particularly in recent years, the disturbance and potential health impacts (not just quality of life but impacts on educational attainment, cardiovascular conditions, etc.) have attracted an increasing level of scrutiny. This has been reflected in the most recent consultations on the draft *Airports National Policy Statement*, the draft *UK Airspace Policy: a framework for balanced decisions on the design and use of airspace*, and the Civil Aviation Authority's guidance on the revised Airspace Change Process. Notwithstanding the current status of these policies, the applicant should still have due regard where they are stricter on noise impacts as this would at least demonstrate best practice. The reference at paragraph 12.10.51 (pg. 12-45) to the consideration of recent draft policy is therefore welcomed. It is also noted that the PEIR uses a Lowest Observed Adverse Effect Level (LOAEL) which is lower than proposed in the *UK Airspace Policy* consultation – the LOAEL being the level of noise at which the average person will begin to experience measurable adverse effects on health and quality of life due to noise exposure.

However, such noise contours show the average level of noise exposure over a defined period of time and therefore they can mask the nature of the individual events that are in fact what is causing the disturbance (and thus the health impacts) in the first place. Consequently, the draft Civil Aviation Authority *Airspace Change Process* guidance and *UK Airspace Policy* propose greater use of N-above metrics, which show the number of noise events in a defined time period as a means of communicating the impact of airspace changes to the public in a manner that correlates with actual experience. The draft *UK Airspace Policy* recognises that increased frequency of aircraft noise, not just average noise overall, is an issue and could require compensation (paragraph 4.48).

As the airspace design has not been undertaken, aircraft noise impacts have not been quantified but a qualitative assessment has been undertaken of the areas that are likely to be adversely affected. During the Airspace Change Process (and assuming that the new Civil Aviation Authority guidance is adopted by this time), the applicant should go through a very rigorous and transparent process of engaging the community in the design options and appraisal of the impacts. Furthermore, there is an understanding of the areas that were affected by noise when the airport was last operational, so this proposal will potentially mark a change to the frequency and volume, rather than the areas affected.

In the case of night noise, the least acceptable form of noise, the PEIR uses the, *"… working assumption for illustrative purposes only that there might be a maximum of eight aircraft movements"* between 2300 and 0700 (paragraph 12.11.21, pg. 12-51), and this is a worst case. The modelling uses the Significant Observed Adverse Effect Level (SOAEL) of 55 dB L_{night}. This is the same level that the World Health Organisation (WHO) showed above which the noise situation is considerably dangerous to public health (2009 Night Noise Guidelines for Europe). The WHO showed effects beginning as low as 40 dB L_{night} and the draft *UK Airspace Policy* LOAEL is 45 dB L_{night} and therefore it would have been beneficial for the applicant to demonstrate the area also affected at this level.

Following the experience in West Kent associated with Gatwick Airport, noise from aircraft, and particularly increased overflight, is a divisive and often unacceptable consequence of living in proximity to an airport. The applicant should go to great lengths to engage local communities in the design of airspace (as part of the Airspace Change Process). It should also be recognised that people are likely to have moved to the area in the period since the airport was closed, and therefore will have no previous understanding of the noise associated with the airport.

Full consideration should be given to re-establishing the Consultative Committee, including representation from any local community groups concerned with noise and environmental impacts. At the appropriate time, a full quantitative assessment should be presented to residents, businesses and others (particularly noise-sensitive sites such as schools and places of worship) who are likely to be affected. This should include frequency contours and a plain-English presentation of the likely number of noise events of a disruptive volume that they will be exposed to in the daytime and night-time periods. The threshold volume should take account of the most recent evidence and research into the health impacts of noise exposure, as reflected in the consultation draft *UK Airspace Policy: A framework for balanced decision making*.

Mitigation for the noise impacts should also be discussed with the local communities alongside a comprehensive package of insulation developed for all those affected. Where mitigation would not be effective (such as for outdoor spaces), financial compensation may be the most appropriate compensation measure. In the design of the flight paths used, where possible, consideration should be given to respite by the use of multiple routes. Given that the consultation documents use 8 flights a night as an indication of the number of likely night flights, then the airport operator should ensure that there is a limit on the noise Quota Count (QC) category of those aircraft arriving between 2300 and 0700, especially given that freighters tend to be noisier aircraft. It may be possible to limit noise at night and the total number of night movements through the provisions and requirements set out in the Development Consent Order - the draft *UK Airspace Policy* encourages a local planning led approach.

Traffic and Transport (Chapter 14):

Resilient and reliable surface access on the strategic road network will be essential for freight traffic using Manston Airport. With the anticipated increase in traffic through growth at the Port of Dover and the future demand once the Lower Thames

Crossing is constructed (anticipated to be 2026), a series of wider network improvements are needed. The location of Manston gives it direct free-flow access between the M2 and the A299, but the M2 has limited capacity being only two lanes in each direction from the A299 to M2 Junction 4.

Kent Highways and Transportation has not been invited by RiverOak Strategic Partners to engage in any discussions relating to this proposal. Therefore the County Council has not had an opportunity to discuss the relationship with an emerging Thanet Transport Strategy. KCC, as Local Highway Authority, would welcome the opportunity to discuss how these proposals could more appropriately reflect or respond to this emerging strategy in due course.

The consultation documents suggest a significant expansion in aviation and other associated operations to those previously present on the site in its former aviation capacity. This in turn would generate a significant increased traffic demand on the surrounding highway network. Therefore the reopening and redevelopment of this site should also be complemented by appropriate highway links. These are currently limited in the locality, particularly to the north east. Given the scale and location of the proposal, an agreed solution to delivery of key strategic improvements in the area will be essential to accommodate increased traffic activity and ensuring that highway safety and amenity is managed in future years.

Paragraph 14.1.5 (pg. 14-1) suggests that the site has good access to the surrounding highway network. However, KCC, as Local Highway Authority, considers that access around parts of the site is not currently satisfactory and consists of local routes with constrained geometry and junctions.

It is suggested that all HGV access to the site would take place from the A299 (via the B2190 approaching the site to its northern boundary). The B2190 Spitfire Way beyond the Manston Business Park is subject to a lower standard (both in terms of restricted geometry and construction) and as such it is likely that this section of road would need to be improved to reflect the proposed uses on the site and the type of vehicle movements associated with it. It is also suggested that staff and passenger terminal vehicles will make use of the full extent of the highway network, which is a reasonable assumption to make as these trips have the potential to be more local in nature.

The proposed complementary business/ industrial uses on the Northern Grass will potentially generate more local based trips, thus rendering local routes such as Manston Court Road and Manston Road as an attractive route to certain destinations. Whilst limited transport information has been provided to date, without a comprehensive package of improvements to cater for trip origins and destinations to the north, the proposals in their current form could lead to the use of inappropriate minor highway routes for both walking and cycling and/ or a proliferation of trips by private car on roads which are not suitable for additional traffic loading.

There is no specific reference to the need for corridor improvements aside from a new junction at Spitfire Way/ Manston Road, although a comprehensive transport assessment will be required by the applicant to provide more fully informed recommendations in relation to wider highway impacts and subsequent mitigation requirements. The emerging Thanet Local Plan seeks to introduce policy to secure an enhanced package of connected highway improvements/ routes, to complement the existing primary highway route corridors. This methodology also forms part of the emerging Local Transport Plan 4. It would appear that with some changes to the proposed layout, there is scope to provide a new highway route through the Northern Grass to connect to Manston Court Road, however an appropriate mechanism to facilitate an improved vehicle/ pedestrian and cycle route to Westwood should also form part of this methodology. This is currently absent from the proposals subject to the current consultation.

Paragraph 14.1.7 (pg. 14-2) indicates that some 4,300 staff could be employed at the airport (with up to 1,500 being present on site at any one time). This represents the potential for a considerable amount of trips for staff alone although no modal split figures are provided. This section also suggests that a high proportion of passengers will travel to the site by private vehicle, either by parked car or drop off, although at this stage it is unclear where these figures are derived from. Rail travel is not listed as one of the possible modes of travel, however there is potential to promote further modal shift in view of the proposed delivery of the Thanet Parkway Railway Station (with appropriate bus shuttle services to complement it). It is considered that Thanet Parkway would significantly enhance the sustainability credentials of the site.

Chapter 9 of the *2017 Consultation Overview Report* makes reference to sections of the highway that could be adversely affected by the project. The list is extremely limited and refers only to the roads immediately surrounding the site. Local impacts on Manston Court Road, Manston Road, the A299 and parts of the A256 are notably absent from this initial list with some of these links being missing from the screening assessment data tables. The nature of the uses intended on the site could have a material impact on the primary road network, which in turn feeds into the strategic road network falling under the jurisdiction of Highways England. It is anticipated that the scope of junctions and links that will need to be assessed will increase as further transport assessment work is undertaken.

Taken at face value, at this stage, it would appear that the proposed uses on the site would make this site a destination for many new and existing residents for work based trips. Therefore it is essential that appropriate links (vehicular and non-vehicular) to the wider highway network are provided to reflect this anticipated demand. Until such time that further transport modelling/ assessment work has been submitted by the applicant, it would be difficult at this stage to identify the extent of any impact and the subsequent mitigation package that might be necessary.

It is essential that any further transport assessment work is fully scoped with Kent Highways and Transportation at an early stage to avoid potential delays later in the Development Consent Order process.

<u>Other Matters</u>

In the period leading to the current consultation, RiverOak Strategic Partners has not engaged the County Council in any meaningful pre-application discussions on the various environmental and technical matters raised in this letter.

The Planning Inspectorate advice[4] emphasises the importance of the Pre-Application stage to all parties involved in the Development Consent Order process and KCC has always sought to proactively engage with applicants on Nationally Significant Infrastructure Projects. The teams who generally have input to such projects continue to experience significant workload pressures and in the absence of any spare capacity, the use of a Planning Performance Agreement (PPA) is justified.

The Planning Inspectorate advises that PPAs should be agreed with the applicant at the Pre-Application stage. Therefore, the County Council would welcome an early opportunity to discuss the preparation of an agreement with RiverOak Strategic Partners, particularly given its intention to submit the application the Inspectorate later this calendar year.

If you require any further information or clarification on any matter in this letter then please do not hesitate to contact me.

Yours sincerely,

[redacted]

Barbara Cooper
Corporate Director – Growth, Environment and Transport

APPENDIX 1: Heritage Conservation comments

[4] February 2015 *Advice Note two: The role of local authorities in the development consent process*

Historic Environment (Chapter 9)	
Para. 9.1.6-9.1.7	It should be noted that the results of archaeological field survey are needed to understand the potential impacts of development. It is likely that the results of geophysical survey and evaluation trenching will be needed to inform the Environmental Statement. Work has been recently been carried out at the Manston Airport site in conjunction with the Stone Hill Park planning application (OL/TH/16/0550). It should be noted that this was specifically tailored against the parameters of that proposal. It may be that the parameters of the proposal led by RiverOak Strategic Partners requires separate additional works to understand the impact.
Para. 9.3.8	The results of survey work are needed to understand the impact of the proposed development on buried archaeology and on historic structures in the airfield. Very preliminary discussions have been undertaken with the applicant, however, the scope of survey work needed should be discussed in further detail with KCC Heritage Conservation and Historic England.
Table 9.3	The response to KCC Heritage Conservation Comment on the need for archaeological evaluation implies a reliance on the results of the survey works carried out for the Stone Hill Park planning application. It is acknowledged that the results of this work will be a data source, it may be that the parameters of those surveys which were specifically targeted against the Stone Hill Park proposals do not cover the parameters of the proposal for which a Development Consent Order is sought. The timetable for when the results of the surveys referred to is made available is also a matter that may influence the production of an informed Environmental Statement.
9.4	The Historic Environmental baseline will need to be strengthened in the forthcoming desk study by a closer examination of the records mentioned and the buried archaeological landscape, and in particular its articulation and significance explained. The baseline presented sets out as a summary of mainly HER entries and does not explain how they come together into a particularly rich and significant archaeological landscape. For example, the western end of the site is the location of one of the highest points in the Thanet District. Examination of cropmarks and other records illustrate that this hill was a particular focus of barrow alignments and cemeteries and these can be identified.
Table 9.8	There are likely to be remains that merit avoidance of impact from the proposal and where mitigation by investigation is an inadequate approach. The need for a decision to be informed by an appropriate and targeted level of survey and evaluation is paramount. Similarly, it is hoped that non-designated historic aviation features are retained as part of the development proposals to ensure that what remains of the historic sense of place is maintained for the future.
Para. 9.6.15	Historic England also requested that the setting of the Minster Abbey Scheduled Monument be included in the assessment (also see Table

	9.3 PINS comment #3). There is also a need to recognise the impact of the proposals on historic landscapes, including the former Wantsum Sea Channel.
Para. 9.6.20	Care should be taken in developing proposals to move the two museums to avoid both direct impacts and indirect effects caused by changes in accessibility, the inter relationship and relationship with the airfield heritage. The potential for enhancement is recognised.
Table 9.11	The should be a recognition that non-designated heritage assets can be of high significance both individually (and the Thanet District has a unique, rich and distinctive archaeological heritage) and cumulatively, as buried landscapes or their contribution to heritage themes that provide a distinctive character to the place.
Table 9.13	The use of a two-level approach may only set out the most significant effects and suggests that lesser effects are not significant. There may be examples especially where Medium Change on Medium Heritage Significance is considered Significant. This could particularly be the case with cumulative effects.
Para. 9.8.4	It is understood that there will be detailed design of construction works at a later phase, however, the Environmental Statement needs to set out clearly the parameters within which the effects of the proposals are appropriately understood so that decisions on the approach to mitigation can be reached.
Para. 9.8.5	It is premature to promote a scheme of archaeological investigation as providing a measure of mitigation. The buried archaeological resource may warrant a scheme of preservation to be agreed in the first instance and where this is not appropriate, mitigation through investigation.
Para. 9.9.2	Built heritage assets within the airport contribute to the historic sense of place of the airfield and should be retained as far as possible. They need to be considered in cumulative terms as well as their individual significance.
Para. 9.14	Direct Effects on Archaeology – the rationale that the archaeology impact can be largely mitigated through investigation is premature and there are likely to be remains that warrant preservation. The further work should include the results of archaeological survey and evaluation tailored for the present proposals. Submitting an outline proposal at application stage will constrain incorporation of preservation measures in the mitigation. Likewise, the significance of the built heritage assets needs to be understood early in design and used to inform the masterplanning of the proposal and detailed design.

Thanet District Transport Strategy

Draft Infrastructure Plan (July 2018)

Feature	Description	Potential Funding Source
Between 1-2	Create New Road Link Between A28 Brooksend Hill and Minnis Road.	On Site (S106)
Between 2-3	Road link between A28 Brooksend Hill and Acol Hill/ B2050.	On Site (S38)(S106)
Between 3-4	Widen B2050 Manston Road between junction with Acol Hill and Shottendane Road.	On Site (S38)(S106)
Between 4-8	Widen / Improvements to Shottendane Road as far as the vicinity of Firbank Gardens, Margate and improve junctions with Park Road, Minster Road and High Street Garlinge.	S106 / External
Between 8-9 & 34	Create new road link between Shottendane Road and Manston Road. Close off Shottendane Road with its existing junction with Manston Road. Create new road link between Hartsdown Road and Shottendane Road.	On Site (S38)(S106)
Between 10-11	Create new road link between Manston Road and Nash Road behind Salmestone Grange and close off Nash Road at its junction of Coffin House Corner.	On Site (S38)(S106)
12	Reconfigure Coffin House Corner Signal Junction. Close off Nash Road Arm and improve capacity and pedestrian facilities.	S106 / S278
13	To reconfigure roundabout at Queens Avenue/Tivoli Road/Grosvenor Gardens and introduce one-way flow on Queens Avenue	S106
14	Marine Terrace Public Realm Improvements (Subject to external funding)	External Funding (CCF…)
Between 15-16	To re-route tourist traffic away from Margate seafront, by providing junction improvements and reintroducing two way flow to Tivoli Road.	External Funding (CCF…)
17	To reconfigure Victoria Traffic Signal junction	S106 / CIL
11-18	Widen Nash Road along its existing alignment	S278 / 38
19	Connect Enterprise Road to Nash Road	S278 / 38
22-23-37	Upgrade Tesco internal link road to adoptable standard between Westwood Road and Margate Road. Extend new link road to Millennium Way between retails parks	External Funding
Between 26– 27	Create new road between Toby Carvery Roundabout and Manston Road to relieve Haine Road Corridor. Improve Approach and Roundabout at Westwood Cross to increase capacity	S106
Between 27– 28	Improve Manston Road between Spitfire junction and Manston Road to Haine Road link	S278
28	Improvements Spitfire junction to increase capacity and improve safety	S278
Between 28– 29	To widen Spitfire Way between Spitfire junction and Columbus Avenue.	S106
Between 29– 4	To extend Columbus Avenue to Manston Road Birchington	S106 / External
30	Improvements to Dane Court Road / Westwood Road Junction to improve journey time reliability	S106
31	Investigate High Street, St. Lawrence/ Newington Road junction to improve air quality and manage congestion	S106
Between 32-34	New Link Road through Manston Green Site and Junction improvements at Manston Road / Haine Road Roundabout	S106
Between 8-35	New Road link between Shottendane Road and Hartsdown Road allowing a new route for traffic avoiding Coffin House Corner	S38 / S278
Between 8-36	Possible new Road link between Shottendane Road and A28 via Garlinge High Street. New signal junction onto A28	S38 / S278
1	Creation of a New Shared Cycleway on the A28 Between Birchington & Garlinge to connect new communities and provide access to secondary schools	S106
2	Improvements to Westwood main junction and adjacent roads to improve bus and cycle provision and improve accessibility and movement for pedestrians between different areas of Westwood Town Centre	S106
3	Construct shared facility on Sloe Lane, Margate	KCC
4	Create shared facility on existing path to the R/O Bromstone School, Broadstairs to connect to Millennium Way to offer alternative to cycling on Rumfields Road	S106
5	Create shared facility on existing footpath between Ramsgate Road, Broadstairs and Dumpton Park Drive, Broadstairs to the side of former Holy Cross School	S106
6	From Ramsgate Railway Station create shared facility on existing footpath to Newington Road	S106
7	From east of Ramsgate Railway Station create shared facility on existing path to Margate Road, provide crossing facility to access Newlands Road and create link to Pysons Road using Newlands Lane	S106
8	Off road section between Convent Road, Broadstairs and the existing off road shared facility further along Joss Gap Road (on edge of golf course)	KCC
9	Between Dent-de-Lion Road, Garlinge and Park Road, Birchington creating (Bridleway) on existing public rights of ways TM27, TM28 & TM23	S106
10	Creation of shared facility on south east side of Dane Park, Margate to link Dane Valley cycle route with Northdown Road, via St Dunstan's Avenue	S106
11	Creation of a shared facility between Canterbury Road West, Ramsgate and Canterbury Road East using existing bridge facility to the east of Haine Road and north of Canterbury Road East	S106

Feature	Description	Potential Funding Source
12	Provide missing shared facility on SW side of St Peter's Road between Broadley Road and Lister Road, Margate.	S106
13	Upgrade footpath TM31 to bridleway to link to bridleway TE12A & link to Shottendane Road improvements to provide shared use pedestrian cycle route.	S106 / 38
14	Improvement of Bridleway TM22 surface to width of 3m as part of Garlinge development.	S106 / 38
15	Upgrade Footpath TM14 on edge of development to Bridleway.	S106 / 38
16	Provide improved surface and widen Bridleway TM11	S106 / 38
17	Provide improved surface and widen Bridleway TM16	S106 / 38
18	Upgrade Footpath TR24 to Bridleway —Crossing point required on Manston to Haine Road Link.	S106 / 38
19	Upgrade Footpath TR24 to Bridleway	S106 / 38
20	Improve surface of Bridleway TR8 and widen to 3m	S106 / 38
21	Creation of new Bridleway and Improve TR32 to link development to future Parkway Station	S106 / 38
22	Improve surface of Bridleway TR10 and widen to 3m	S106 / 38