

Managing Aviation Noise

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CHAPTER 1

Executive summary



Aviation noise currently affects more people in the UK than any other country in Europe. It affects the quality of life of those who live close to airports, provokes strong feelings among local communities, and is central to the Airports Commission's work on aviation capacity.

As the consumer champion for UK aviation, the CAA's objective is to ensure that people have access to a variety of options when choosing to travel by air, offering good value for money across a range of prices. We believe that without building another runway in the south east, consumers will suffer from higher prices, reduced choice and falling service quality.

However, building a new runway to benefit consumers cannot be achieved at the expense of the overflown. Aviation must manage its impact on the environment and on those living close to airports if it is to expand.

The CAA believes that any proposal to increase airport capacity in the UK must show that it is sustainable, must abide by the Government's aim of limiting and where possible reducing aviation noise over time, and must ensure that where communities are affected by noise, the impact is minimised, mitigated and compensated appropriately.

As such, it is important that policymakers, the aviation industry and stakeholders unite in an effort to confront the issue of aircraft noise in an ongoing, practical, and transparent manner to provide communities the reassurance they need that capacity expansion will not come at a cost to their quality of life.

This document offers the aviation industry and policy-makers a selection of options that are available to manage aviation noise. Many of these suggestions are applicable to any airport in the UK where there are noise issues. However, in the context of the Airports Commission's shortlisted options, there are also a series of recommendations related to the most effective ways to manage noise when capacity is expanding.

The document structure is as follows:

Context – this chapter examines the context around aviation noise and capacity expansion in the UK, as well as explaining the CAA's role and considering the work of the Airports Commission.



Measuring aviation noise – the methodology behind measuring, assessing and describing noise is important context in this area, so this chapter provides background on how aviation noise is measured, in the UK and Europe, and its effects on people.

Quieter aircraft design – this chapter reviews the significant advances in aircraft design over the past fifty years which have resulted in reductions in noise, and considers the potential for future manufacturing improvements in noise performance.

Operational approaches to noise – here we review current operational approaches to minimising aircraft noise, detailing techniques which are being operated by industry in some areas or other countries; are being trialled; or are being explored for future trials. Many of these techniques are complementary, although adopting some may rule others out, and some may involve tradeoffs with other priorities such as airspace or runway capacity, engine life, and fuel burn/carbon emissions, which would need to be factored in to a cost benefit analysis as part of decision making.

Mitigating noise on the ground – given that even factoring in advances in manufacturing and utilising of noise-minimising operational strategies, it is unlikely that aircraft noise can be reduced to a level that annoys no one, this chapter looks at tactics including insulation, glazing and sound barriers to mitigate aircraft noise.

Incentivising the industry – generally we believe the aviation industry is incentivised to reduce noise. However, the CAA believes that in the UK, the failure to adequately engage communities and reduce noise to tolerable levels for more people has seen attempts to expand runway capacity fail. Therefore, potential incentives to ensure industry are focussed on the right outcomes to allow capacity to develop following the Airports Commission final report are explored in this chapter.

Engaging the community – Community engagement is key to delivering additional runway capacity. Experience overseas indicates that a sustained, transparent and genuine attempt to ensure communities have a say in decision making and experience the positive side of additional capacity and not only the disbenefits, enhances the potential for success when creating additional airport infrastructure. This chapter explores potential strategies adopted at overseas airports and other sectors within the UK.

The international picture – building on the previous chapter, the document closes with two case studies of successful attempts to create new runways and airport facilities, at Frankfurt and Amsterdam, attempting to draw lessons from their experiences which can be applied within the UK.

Recommendations

Key recommendations for the aviation industry include:

- Airports and airlines should ensure that operational approaches to mitigate noise are incentivised and adopted wherever feasible. The CAA will work with industry to consider, trial and promote novel operational approaches to noise minimisation.
- When looking to expand, airports should do more to ensure local residents see benefits from additional capacity – whether through funding community schemes, direct payments, or tax breaks.
- Airports seeking expansion should significantly increase spending on noise mitigation schemes to get closer to international competitors – including full insulation for those most affected.
- Airlines should focus on noise performance when purchasing new aircraft.
- Airports should structure their landing charges to incentivise airlines to operate cleaner, quieter flights.



In addition, the document proposes creating a new Airport Community Engagement Forum bringing together local residents, the aviation industry, policy makers and planners focussed on how new capacity can developed and operated to minimise noise impacts and maximise community benefits, rather than whether it should be built.

Measures that Government and local authorities could consider include the potential for tax breaks for local people and businesses and, if other methods are not successful, the potential for a future noise tax to incentivise airlines to procure and operate fleets in the most noise efficient fashion possible and to internalise noise impacts in consumer decision making.

The CAA is committed to leading the debate around aviation noise – driving changes that reduce noise, and challenging the aviation industry to do more to work to manage its noise impact and engage those communities who feel that impact the most. Without this focus, we do not believe that attempts to build a new runway in the south east will succeed, so we look forward to discussing our recommendations with the aviation industry, local communities, government, and the Airports Commission themselves, before ensuring that all parties are united in the common goal of cutting aviation's noise impact on communities.

CHAPTER 2

Context

Aviation noise negatively affects more people in the UK than any other country in Europe. Noise from Heathrow at a level classified as significantly annoying impacts more people than any other airport in Europe. In fact, Heathrow's noise footprint in terms of population affected at the European standard measure¹ is larger than the next five European airports added together².

Although noise performance has improved dramatically over the past fifty years, community perception of noise has if anything worsened. There are a number of reasons for this, but it firmly places an onus on the aviation industry and policy-makers to do more to tackle aviation noise.

Aviation's environmental impacts have a clear impact on the sector's ability to develop to serve consumer demand. In the UK, we have developed only one brand new runway capable of serving large, modern aircraft since the Second World War, at Manchester Airport. The planning process for the creation of a fifth terminal at Heathrow Airport was the longest in history, and resulted in reforms to the system to try and avoid similarly expanded timescales during the development of future nationally significant infrastructure. Across the country, where airports have changed their usage from military to civil, or seen capacity expansion or terminal and taxiway development, local protests have been common.

As such, aviation's environmental externalities have a clear impact on choice and value for consumers. Tackling these issues offers the potential to improve life for passengers by facilitating a more effective development approach that delivers additional capacity where it is genuinely necessary.

- 1 The standard European measure is the 55 dBA L_{den} noise contour. In the UK, our long-term metric for the onset of significant annoyance at aviation noise has been 57 dBA L_{eq} contour. Throughout this document, we take the 57 dBA L_{eq} contour, as the UK's current accepted representation of the onset of significant annoyance, to allow comparison on a like-with-like basis. However, as explored in Chapter 2, there are a variety of competing and complementary metrics available to represent aviation noise, and use of 57 dBA L_{eq} should not be interpreted as a belief that it is the sole effective measurement.
- 2 European Environment Agency, Noise Observation and Information Service for Europe (NOISE). Comparative interactive and raw data available through the Noise Viewer: <http://noise.eionet.europa.eu/viewer.html>

Key to this, and the area where the aviation industry has a significant number of tools at hand to improve performance, is noise. It has been argued that noise, more than any other factor, has contributed to the log-jam that has seen a series of South East runway capacity expansion schemes tabled by government before falling by the wayside as various factors have stopped their development.

Alongside reducing noise, greater community engagement is vital to enhance trust and give those affected confidence that they can gain accurate, practical information about aviation and its noise impact.

In 2012, the CAA published [Aviation Policy for the Environment](#) which set out why the CAA feels that supporting an environmentally sustainable aviation industry is vital for government aviation policy. This included making a series of observations around what types of actions could improve noise performance and support local communities' engagement with aviation around noise. This document builds on those suggestions and updates on progress in delivering improvements - making recommendations for actions from industry and policy-makers where appropriate.

The historical picture

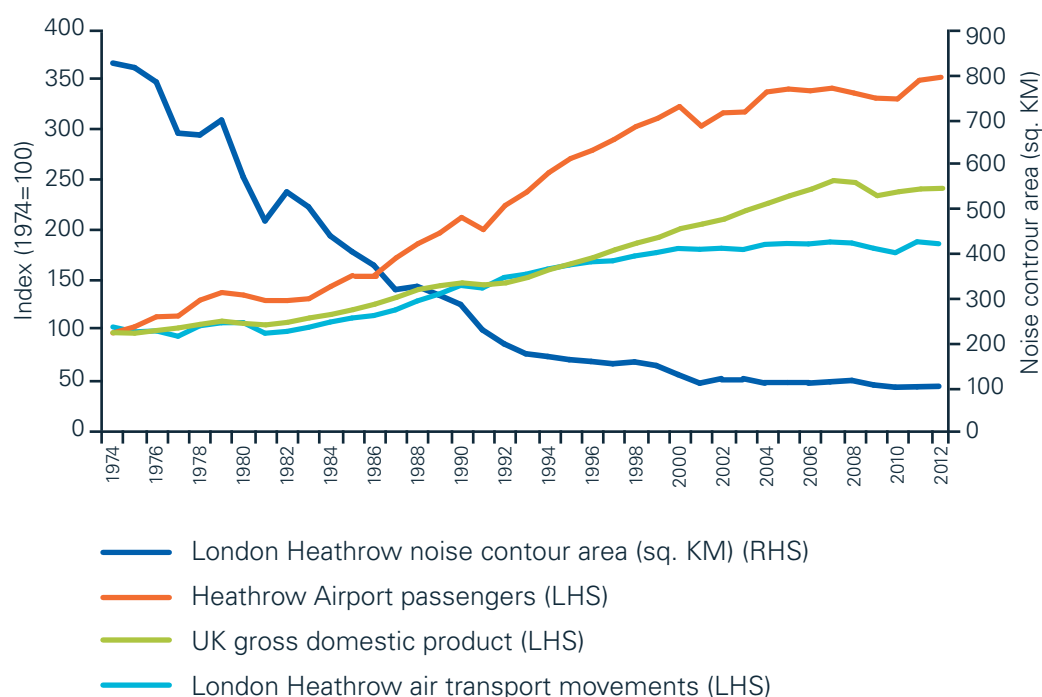
Concerns about the noise impact of aviation date back to the 1950s and 1960s as jet engine technology became more commonplace, and international aviation became more popular in Europe and the United States. The advent of wide-bodied, jet-engined aircraft and the dawning of the jet age of international travel saw the beginnings of protest about how aircraft noise impacted on local communities around airports, and given the significant noise impact of the early jets, how even areas quite significant distances away from airports were affected.

Around this time, local communities and environmentalists began to form the first groups dedicated to reducing and removing aircraft noise from their areas. The Kew Association for the Control of Aircraft Noise, which grew into HACAN ClearSkies was founded in the mid-1960s, the Gatwick Area Conservation Campaign began its work in 1968. These groups have grown in membership and influence as flight numbers have increased and airports have grown.

Over the past half century, flight numbers have increased significantly, while the performance of aircraft has improved, especially in terms of noise and fuel efficiency. At the same time, UK GDP has increased steadily, population growth has significantly increased, and quality of life

has improved for people. These factors all have an impact on the effect of aviation noise on local communities and their perception of it. Figure 2.1 highlights that despite this growth the noise contour area has reduced by almost 90 percent since the early 1970s. There has, however, been little improvement since 2000, and whilst the noise level per flight has dramatically reduced, some residents experience significantly more noise events than they did in the early 1970s.

Figure 2.1 - UK GDP, Heathrow growth and noise exposure 1974-2012³



Source: CAA statistics and noise modeling data; ONS GDP data.

In 2013, the Department for Transport published its Aviation Policy Framework⁴, setting out, amongst other things, the Government's approach to aviation noise.

³ Prior to 1990, the noise contour benchmark area and populations was based on the 35NNI contour, approximately equivalent to 57 dBA L_{eq} . From 1990, benchmark area, populations based on the 57 dBA L_{eq} contour.

⁴ Aviation Policy Framework, March 2013: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/153776/aviation-policy-framework.pdf

The Government's stated high-level policy on aviation noise is to limit and, where possible, reduce the number of people in the UK significantly affected by aircraft noise, as part of a policy of sharing benefits of noise reduction with industry. This approach aims to strike a fair balance between the negative impacts of noise and the positive economic effects of aviation.

In 2001 the Advisory Council for Aeronautics Research in Europe (ACARE) published their Vision 2020 report, which highlighted the targets the European aviation industry aimed to meet by 2020 to secure a sustainable future. This included a target to reduce external aviation noise by 50% (equivalent to a 10 dB reduction).

Recent research has begun to highlight that aviation noise is not only an issue that causes communities irritation and annoyance, but that prolonged exposure to noise, particularly at night, is linked to long-term health issues. Although researchers are not clear on the exact nature of the relationship between night noise and public health, it seems that disrupted sleep or the stress caused by noise may increase the risk of heart disease in people who live close to airports under flight paths for long periods of time⁵.



5 A CAA study of recent research on the health impacts of aviation noise can be found here: <https://www.caa.co.uk/docs/33/ERCD1208.pdf>

ICAO's balanced approach

The measures set out in the following chapters are designed to reflect the Balanced Approach to Aircraft Noise Management⁶ set out by the International Civil Aviation Organisation, the UN mandated body that governs global aviation. The balanced approach defines four pillars to managing noise:

- Noise reduction through technology
- Improving noise perception through better land use planning
- Noise reduction through better operation
- Operating restrictions on aircraft if the other three pillars are exhausted

This document does not comment on land use planning as our general approach is to consider opportunities industry and government have to improve noise impact on those currently affected. In addition, in focussing on developing capacity at the Airports Commission shortlisted sites, minimising the impact on existing communities should be the focus.

However, it will be important to ensure that when capacity is developed planning policy reflects an objective of minimising development within areas significantly affected by noise.

We agree with the aviation industry that it is crucial to ensure that development at UK airports is managed to reduce noise impacts - and welcome their sustained focus on this important aspect of the balanced approach. We firmly support attempts to limit the introduction of new residential and social developments within areas heavily impacted by aviation noise.

A holistic approach to planning and land management would see attempts to limit aviation noise at source combined with a strategy to over time reduce the people living in areas where mitigation will always be challenging. If this were implemented by government and strictly controlled, over time there is the potential to reduce the population affected by significantly annoying levels of noise to close to zero at many airports.

6 Guidance on the Balanced Approach To Aircraft Noise Management, ICAO Doc 9829 AN/451, Second Edition 2008

Aviation capacity in the UK

Development of UK airports has tended to be piecemeal and sporadic, as can be expected with private sector funding of infrastructure: capacity will not be developed until demand supports it, and peaks and troughs are inevitable. However, full scale runway development has been incredibly rare given the UK's advanced aviation market, and strong demand for international travel. Since the 1950s, only two new runways have begun operation across the country, a second runway at Manchester, and London City's short runway, which is unsuitable for the largest modern aircraft. Aside from that, all runway development has seen former military airfields repurposed for civil use, from the transfer of the Great West Aerodrome to civil use in 1946 as London Airport (becoming Heathrow Airport in 1965) to RAF Finningley becoming Robin Hood Doncaster Sheffield Airport in 2005 and RAF St Mawgan becoming Newquay Airport in 2008.

There is certainly no shortage of ideas about where airport capacity could be developed, with dozens of proposals put forward, whether in addition to existing capacity or to replace airports in more congested areas of the south east.

During this period though, airports, planning authorities and government have all struggled to overcome local community objections to development, with a number of approaches taken to try assuage concerns, often with the paradoxical result of weakening trust where promises are breached. A clear indication of this issue is the situation at Heathrow in relation to perceived commitments made during the planning inquiry for Terminal Five that no further development would be required in future. During the development of the 2003 Aviation White Paper and subsequently, the perception that this promise had been broken has been a talismanic issue for local communities⁷.

The CAA's view is that while it is not the sole reason for communities objecting to airport expansion, noise impact on nearby residents significantly reduces the potential to increase airport capacity, particularly in the south east.

⁷ See for instance Friends of the Earth, Heathrow terminal 5 and runway 3. A chronology of worthless promises: 1993-2008: http://www.foe.co.uk/sites/default/files/downloads/heathrow_broken_promises.pdf

HACAN ClearSkies news release, 13 March 2008:

http://www.hacan.org.uk/news/press_releases.php?id=211

Noise is also an area where the aviation industry has access to a series of tools that can improve life for those who live close to airports, potentially helping to unblock the process of delivering new capacity. Also, noise may affect greater numbers of people than other local issues such as air quality - anti-noise groups report complaints about aircraft noise (especially early morning or late evening noise) as much as 20 miles from the airport.



The Airports Commission

The [Airports Commission](#) was set up in late 2012 by the Government to examine the scale and timing of any requirement for additional capacity to maintain the UK's position as Europe's most important aviation hub, and it will identify and evaluate how any need for additional capacity should be met in the short, medium and long term.

In December 2013, the Commission published its Interim Report, setting out its assessment that the UK required one additional net runway to be developed in the period to 2030, and shortlisting three possible candidate proposals - two options at Heathrow Airport and one at Gatwick. In addition, it committed to further study of a proposal to develop a new airport in the Thames Estuary, and published a series of short term proposals to better utilise existing capacity.

By summer 2015, the Airports Commission is expected to report on:

- its assessment of the options for meeting the UK's international connectivity needs, including their economic, social and environmental impact;
- its recommendation(s) for the optimum approach to meeting any needs; and
- its recommendation(s) for ensuring that the need is met as expeditiously as practicable within the required timescale.

As part of its final report the Commission is expected to provide materials to support the government in preparing a National Policy Statement to accelerate the resolution of any future planning applications for major airports infrastructure.

More details about the Airports Commission's role can be found in its [Terms of Reference](#)⁸.

8 <https://www.gov.uk/government/organisations/airports-commission/about/terms-of-reference>

The CAA role

As the UK's independent aviation regulator, many of the CAA's functions cut across the aviation noise and aviation capacity spheres. The CAA houses the UK's expert noise monitoring and modelling function within its Environmental Research and Consultancy Department (ERCD).

As airspace regulator, the CAA has a statutory duty to consider the environmental impact of aviation when taking decisions in relation to proposed changes. In addition, in December 2012, the CAA was given a duty to publish environmental information on the effects of aviation on the environment. With this new duty, the CAA is intending to consolidate existing aircraft noise information and implement new tools to improve the public understanding of the effects of aircraft noise.

On airport capacity, the CAA has set out its view that without a credible, long-term policy framework that allows capacity to develop sustainably, it is likely that prices will rise, route choice will drop and the UK economy will suffer⁹.

Additional capacity would offer significant benefits for consumers, and for the UK as a whole, so long as it is delivered in an environmentally sustainable way.

Previous work for the Airports Commission

The CAA collects a broad range of statistics and survey data, and has drawn on these resources to provide analysis to the Airports Commission in order to inform some elements of its phase one process to sift proposals into a short list.

The CAA's previous contributions to the Airports Commission and other work on aviation capacity policy can be found at <http://www.caa.co.uk/default.aspx?catid=589&pagetype=90&pageid=14751>

Our other publications relating to aviation capacity in the UK can be viewed here: <http://www.caa.co.uk/default.aspx?pageid=12375>

9 Aviation Policy for the Future, January 2012, http://www.caa.co.uk/docs/589/CAA_InsightNote3_Aviation_Policy_For_The_Future.pdf See also, Andrew Haines, CAA Chief Executive, speech to the Runways UK Conference in January 2014: <http://www.caa.co.uk/docs/14/Andrew%20Haines%20speech%20to%20the%20Runways%20UK%20Conference%2016%20January%202014.pdf>

CHAPTER 3

Measuring aviation noise

Noise effects on people

Many different effects of noise can be identified and people experience each of them differently. For the practical assessment of any particular effect, it is necessary to define an appropriate indicator of reaction to correlate with a noise exposure measure. Although there is no standard classification of effects, they can be divided into (a) behavioural indicators of well-being showing how noise may interfere with normal living and (b) physiological/medical indicators of chronic health effects such as noise induced hearing loss or other symptoms that may be linked to noise exposure. These include¹⁰:

- Detection/distraction
- Speech interference
- Disruption of work/activity
- Sleep disturbance
- Noise-induced hearing loss
- Stress and other health risks

The first four elements are generally considered as those that lead to a second level of behavioural reaction, sometimes viewed as an indirect response to disturbance of different kinds, that is, annoyance. A third level response is overt reaction including complaints. The last two elements in the list above are considered physiological/medical indicators. Noise-induced hearing loss is normally associated with occupational noise exposure and is an extremely rare occurrence in the context of transport noise exposure. There is increasing evidence that these may occur through both conscious (for instance stress) and sub-conscious responses (for instance raised blood pressure)¹¹.

¹⁰ WHO (1999), "Guidelines for Community Noise", WHO, 1999.

¹¹ WHO (2011), "Burden of disease from environmental noise. Quantification of healthy life years lost in Europe", ISBN 978 92 890 0229 5, WHO, 2011.

The phrase community annoyance is the most useful general catch-all of overall, long-term aircraft noise impact, which can also be correlated with long-term average noise exposure.

The predominant source of transport noise exposure is from road noise. The European Environment Agency reported that within Europe's major cities approximately 70 million people are exposed to road noise above 55 dB L_{den} , compared with just under 10 million to rail noise and less than 3 million to aircraft noise¹². Notwithstanding these findings, aviation noise generates considerable interest as it tends to cover larger geographical areas and is more difficult to mitigate when compared to road and rail noise.

Some noise effects have been measured objectively and quantitatively, and related to noise exposure indicators. These include speech disturbance and noise induced levels of hearing loss. However, some behavioural indicators, including annoyance, are essentially subjective and, although quantifiable, can be affected by non-acoustic factors such as location, activity, well-being, familiarity with the noise, environmental expectations and attitudes to the noise makers. The effects of such modifying factors dramatically weaken correlations between noise and response indicators. Such relationships are further obscured by variations in noise exposure over time and space, because people move around and engage in different activities.

Obvious physical factors include time and situation, which govern intrusions into activities - sleep disturbance occurs primarily at night, speech interference during the day and so on. But equally important are those that control attitudes and susceptibilities; whether or not a particular noise annoys may depend very much upon the message it carries; concerns about the sources of noise can influence annoyance reactions as strongly as physical noise exposure itself.

Because of the combined influences of acoustical and non-acoustical factors, it is increasingly difficult to isolate the underlying noise-response relationships for the higher level responses. Thus, the probability of speech disturbance is strongly dependent on acoustical factors - the characteristics of the speech and the background noise. Whether or not this would result in annoyance depends on a set of modifying socio-psychological factors. Finally, the possibility of consequent overt reaction depends on the annoyance but also upon even more modifying factors.

¹² TERM Report 2012: Transport indicators tracking progress towards environmental targets in Europe, EEA Report No 10/2012.



Taken together, information on relationships between noise exposures and their potential adverse effects upon people is of variable quality. Some relationships stem from extensive research and are reasonably well corroborated and widely used; others are fragmentary and insufficient to provide reliable criteria. In general, practical noise assessment methodology has to be consistent with the understanding of the factors involved. Because effects on the community as a whole can only be described in broad statistical terms, noise exposures are commonly defined only as long-term averages at representative locations.

Annoyance as an indicator of community impact

While some noise-effect relationships can be quantified, others cannot. Noise disturbance and short-term annoyance have been studied extensively in research laboratories. In such studies, jury subjects listen to test noises generated by loudspeakers or headphones and their responses are recorded and correlated with the measured noise levels. Such experiments can be performed with great accuracy and they have provided a wealth of knowledge about the fundamental characteristics of human hearing and perception of sound. Particularly important products of this kind of work are the various decibel scales used to define and measure noise and noise events in terms that can be related to human perception, such as A-weighted sound level and Effective Perceived Noise Level.

A detailed understanding of specific disturbance criteria is not particularly helpful when it comes to assessing the day-by-day impact of environmental noise on communities.

The noise experienced by individuals obviously depends on where they live and work and upon their lifestyles; no two people experience exactly the same noise exposure patterns over a period of time or the same interference with their activities. And different people react differently to the same noise; some are a great deal more sensitive than others. Coupled with the range of potential disturbance effects, these variations make studies in the community intrinsically much more complex than laboratory work. Yet it is only in the real world that the relationships between cause and long-term annoyance - as a consequence of total long-term noise exposure from all sources - can be investigated.

This long-term aspect of cause and effect has been the primary influence on the direction that field research on noise effects in the community has taken. Community annoyance has been adopted as a general indicator for all of the possible impacts of environmental noise. In social survey studies, individuals' annoyance has been measured in a variety of ways - quantifying it on simple numerical or category scales or via elaborate multi-question procedures. These measurements have then been correlated with various measures of typical noise exposure, first to decide what is the appropriate scale or metric, and then to 'calibrate' the scale, that is to determine the exposure-response relationship. In such correlations, the overall impact of noise is sometimes expressed as an average across individuals or, alternatively, as the incidence of high annoyance (such as the percentage of respondents 'very much annoyed').



Measure of long term noise exposure

The levels of individual noise events are required for many purposes including aircraft noise certification. However, in order to assess environmental noise exposure, it is necessary to consider and take account of many events over a longer term, events which may differ in magnitude and be either repetitive or isolated.

The practical benefits of being able to express both long- and short-term noise exposures and limits by simple, single-valued indices are obvious. Equally, long- and short-term measures should be able to be linked effectively. Without such tools it would be very difficult to make informed comparisons of noise exposure changes over time, whether these are concerned with historical trends or making judgements about the effectiveness of alternative noise control measures and/or changes in the number and intensity of noise events.

A noise index should be simple, practical, unambiguous, and capable of accurate measurement (using conventional, standard instrumentation). It must also be suitable for estimation by calculation from underlying source variables and robust - not over-sensitive to small changes in input variables.

Long term noise exposure levels have been quantified in a variety of ways. These ways have been dictated partly by available instrumentation and partly by the nature of the events and their relationship to background levels, which are in turn controlled by other sources. One such measure is L_n , representing the sound level exceeded for $n\%$ of the measurement period. For example, in situations where the instantaneous sound level is continuously fluctuating, L_{90} and L_{10} can be used to characterise general and typical high levels respectively. In the UK, a particular version of L_{10} is used to specify levels of exposure to road traffic noise.

Nowadays, the most commonly used noise exposure measure for all sources is the Equivalent Continuous sound Level or L_{eq} and, for aircraft noise, this is in widespread use around the world.

The adoption of L_{eq} as the UK Aircraft Noise Index followed extensive surveying of attitudes to aircraft noise and resulted in a dose-response relationship linking levels of community annoyance to L_{eq} ¹³. This also built on the past use of NNI, where for policy purposes three specific levels were defined to represent low, moderate and high annoyance based on preceding surveys of noise attitudes. In transitioning from NNI to L_{eq} , it was logical and convenient to continue this approach and define three levels of L_{eq} corresponding low, moderate and high annoyance, which were subsequently defined as 57, 63 and 69 dBA L_{eq} ¹⁴.

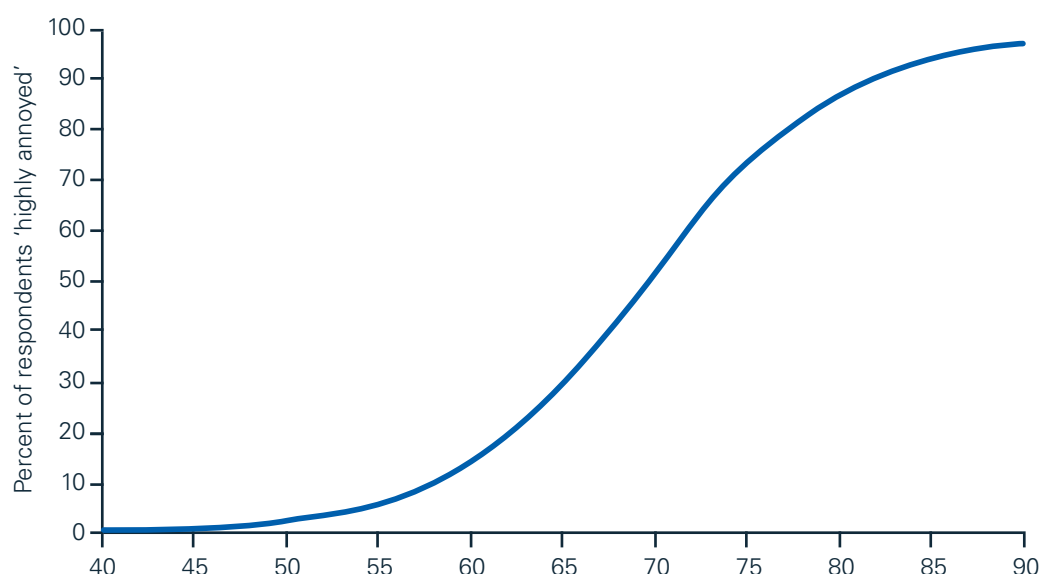
In defining these three levels for policy purposes, it is sometimes forgotten that aircraft noise results in a very wide range of responses from individuals. Whilst aircraft noise attitude surveys have shown that 57 dBA L_{eq} represents overall low annoyance, they also show that around 10 percent of people would describe themselves as highly annoyed at this level, as shown in Figure 3.2¹⁵.

13 Brooker P, Critchley J B, Monkman D J and Richmond C G "United Kingdom Aircraft Noise Index Study: Main Report" DR Report 8402, January 1985.

14 Crichtley JB and Ollerhead JB, "The use of L_{eq} as an Aircraft Noise Index, DORA Report 9023, Civil Aviation Authority, September 1990.

15 CAP 725, "CAA Guidance on the Application of the Airspace Change Process – Environmental Requirements", Civil Aviation Authority, March 2007.

Figure 3.2: Percent of survey respondents 'highly annoyed' as a function of 16-hour L_{eq} noise exposure level



As can be seen, reaction to aircraft noise begins to change markedly around 57 dBA L_{eq} , resulting it being adopted a key policy level for those significantly affected by aircraft noise.

The CAA acknowledges that the relationship shown in 3.2 above is based on a 1982 noise attitudes survey and that some stakeholders consider the relationship to be no longer valid. We believe that any noise metric and levels used for policy assessment should be evidence-based and support the need for a new aviation noise attitude survey.

Although there has been a gradual convergence towards L_{eq} based noise metrics for aircraft noise (as well as road and railway noise), some countries continued to use their own national metrics adopted during the 1960s and 1970s. The European Union recognised that harmonisation of noise indicators was an essential component of the European strategy to reduce noise and that harmonised indicators would enable direct comparison of noise situations in different Member States, facilitate the exchange of information between Member States and local authorities, and that they would support more consistent assessment of the costs and benefits of noise control measures.

An EU Noise Working Group subsequently recommended¹⁶ the adoption of two indicators, the 24-hour L_{den} indicator to assess annoyance and the 8-hour L_{night} indicator to assess sleep disturbance.

¹⁶ EU Directorate-General, "Position paper on EU noise indicators", European Communities, ISBN 92-0828-8953-X, 2000.



L_{den} incorporates the same basic form as the L_{eq} noise index, including the same weighting between event noise levels and number of events. However, it differs in that L_{den} covers 24 hours over a full year, whereas the UK noise index covers 16 hours (0700-2300) over the three summer months from mid-June to mid-September. The L_{den} 24 hour period also incorporates weightings for certain hours within the 24 hour period. The four-evening period (1900-2300) includes a weighting factor of 3.16 on each hour, effectively meaning that the noise energy of a single evening flight is weighted as 3.16 times a single daytime flight. The night period (2300-0700) includes a factor of 10 weighting, such that a single night flight counts as ten day flights.

The difference between a 24 hour L_{den} value and the 16 hour L_{eq} value at any given location is not constant, but varies depending on the proportion of noise in the day, evening and night periods and depending on the specific location. For typical UK airports, the L_{den} level is approximately 1.8 dB higher than the 16 hour L_{eq} .

The levels of L_{den} to be assessed and reported were subsequently set as 55 to 75 dB L_{den} and 50 to 70 dB L_{night} in the Environmental Noise Directive¹⁷, reflecting the WHO position in their 1995 guidelines that “few people are seriously annoyed at L_{eq} levels below 55 dB”¹⁰.

Some situations, however, cannot readily be dealt with by simple L_{eq} assessments. This is especially true when contributory noise events vary substantially and/or irregularly. Care has to be taken to consider the distribution of events and in choosing the most appropriate assessment period. For example 8-hour L_{eq} may provide a good indication of noise exposure on a factory production line if the pattern of noise changes little from hour to hour during that period. It may also provide a good basis for comparing noise exposures between different production lines. But care must be taken to ensure that the period chosen is reasonable for all the production lines being compared. In other words, the period over which L_{eq} is calculated has to be relevant to the pattern of noise exposure and any comparisons have to be on the basis of like for like.

The same principle applies to noise from aircraft and from other sources. Thus changes in the distribution of noise exposure through the course of a day will not be reflected in a standard 16-hour L_{eq} noise index. Although the day, evening, night, L_{den} index, will capture the effect of re-distributing noise between the day, evening or night periods, it will not capture the effects of a redistribution of noise within each of the periods.

This can be addressed by the use of supplemental metrics, e.g. use of the L_{eq} noise index over a shorter time period, or by using other metrics that provide greater information on the variation of noise level and number of events over time. The challenge that arises with supplemental metrics is that there is no evidence to inform the critical threshold values to adopt, nor the weighting to be assigned to each metric.

¹⁷ EU Directive 2002/49/EC, 18th July 2002.

CHAPTER 4

Manufacture: Quieter aircraft design

The historic picture

There is no doubt that over more than fifty years of the jet age, technology has significantly improved aircraft noise performance, to the point that in 2012, the 57 dBA L_{eq} aircraft noise contour area around Heathrow covered just over a tenth of the area it did in 1974. Even considering significant population growth, 2012 saw a near ten-fold reduction in people within the contour compared with 1974. Gatwick has seen similar reductions, with the 57 dBA L_{eq} contour area now around 20% of the size it was in 1979 when noise contours were first generated, and the population affected by that level of noise is just over 10% of the number it was in 1979.

