



Managing Aviation Noise

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Contents

Executive summary	2
Context	6
Measuring aviation noise	15
Manufacture: Quieter aircraft design	24
Operate: Limiting noise through operational approaches	32
Mitigate: Reducing noise on the ground	47
Incentivising the aviation industry	55
Engaging the community	64
The international picture	71
Recommendations	76

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 Lden noise contour. In the UK, our long-term metric for the onset of significant annoyance at aviation noise has been 57 dBA Leq contour. Throughout this document, we take the 57 dBA Leq 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 Leq 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

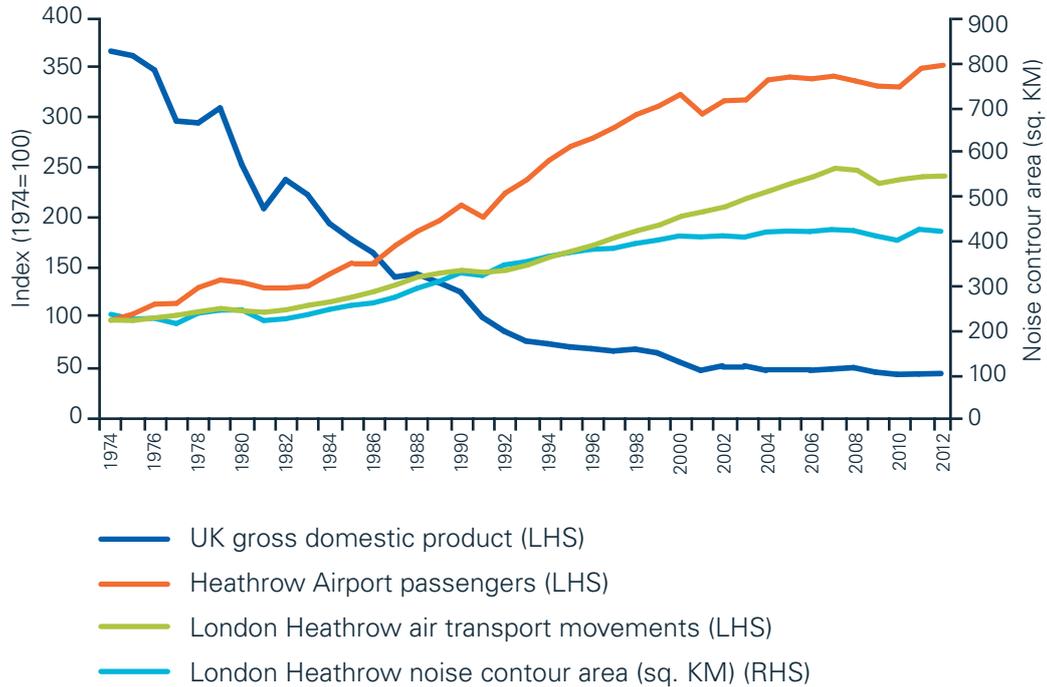
Concerns about the noise impact of aviation date back to the 1950s and 1960s as jet engine technology became more commonplace, and international aviation became more popular in Europe and the United States. The advent of wide-bodied, jet-engined aircraft and the dawning of the jet age of international 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 57dBA Leq. From 1990, benchmark area, populations based on the 57dBA Leq 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, L90 and L10 can be used to characterise general and typical high levels respectively. In the UK, a particular version of L10 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.

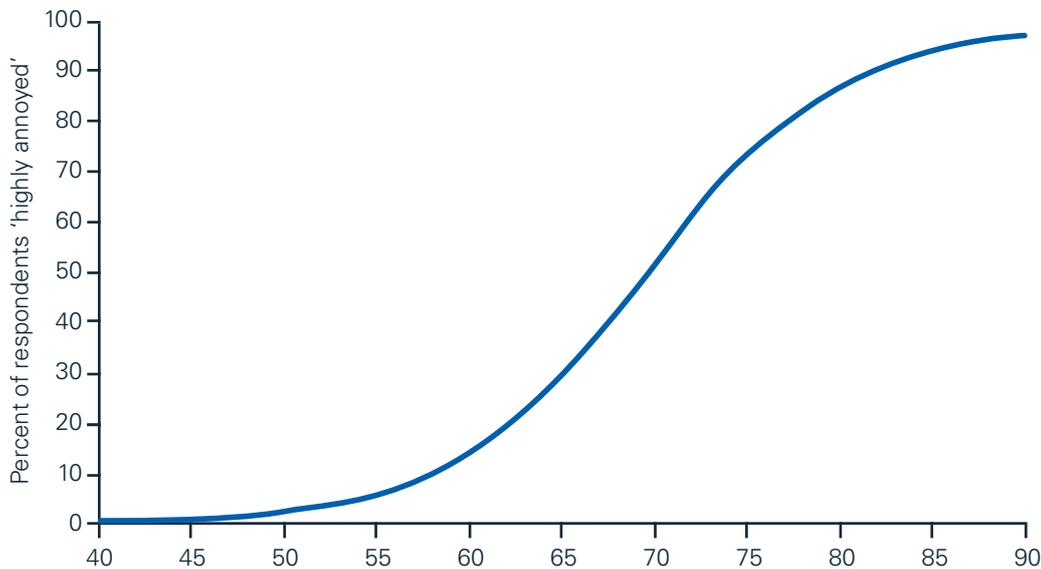
In defining these three levels for policy purposes, it is sometimes forgotten that aircraft noise results in a very wide range of responses from individuals. Whilst aircraft noise attitude surveys have shown that 57 dBA L_{eq} represents overall low annoyance, they also show that around 10 percent of 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 Critchley JB and Ollerhead JB, "The use of Leq 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 in it being adopted as 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.



Figure 4.1 below indicates the recent reductions in aircraft noise of comparable aircraft types between the most recently introduced aircraft (A380 and B787) and comparable types (B747-400, and A319, and A320 respectively). The take-off noise footprint of the Boeing 777 fits somewhere between the higher passenger capacity A380 and B747 and the three lower capacity aircraft types, depending on configuration.

Figure 4.1: Heathrow departure 90 dBA SEL contours on 27L CPT for selected aircraft

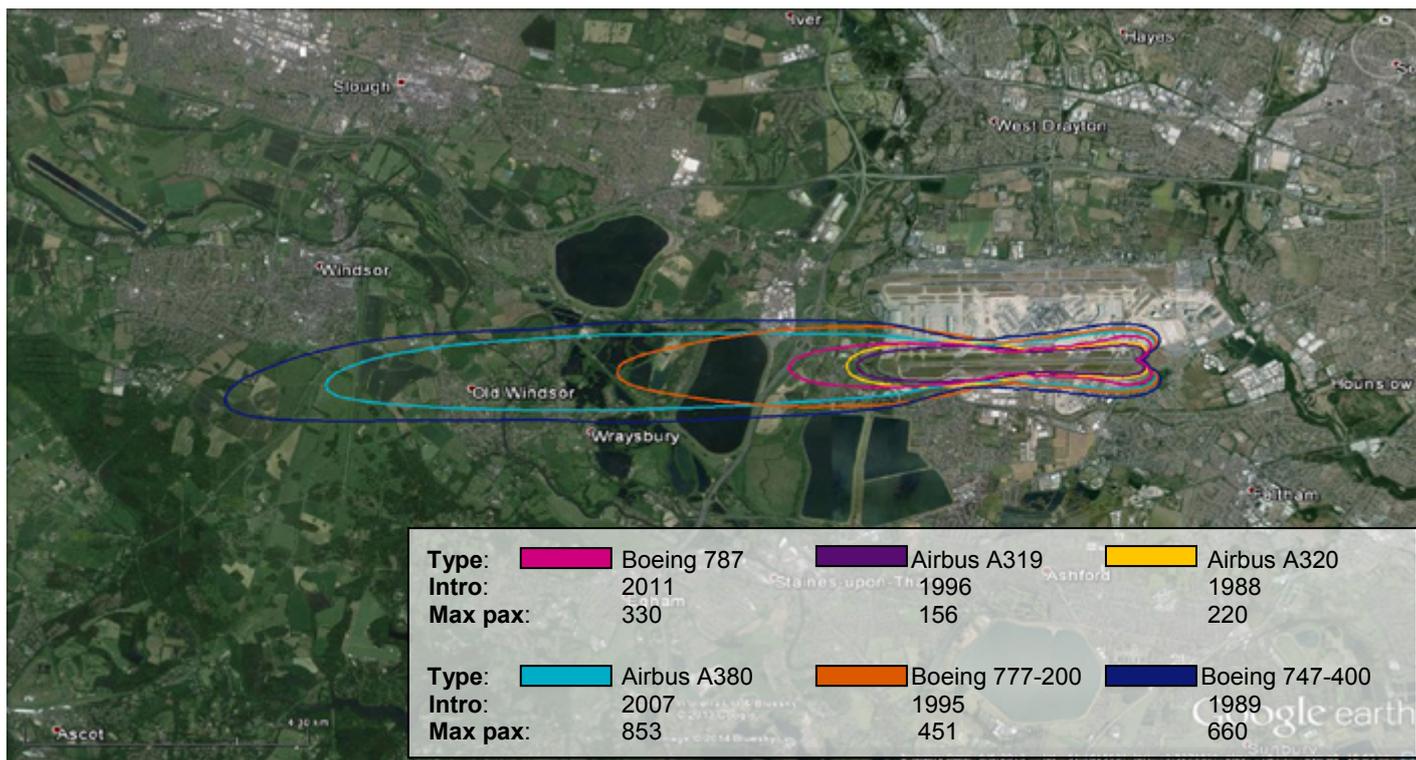
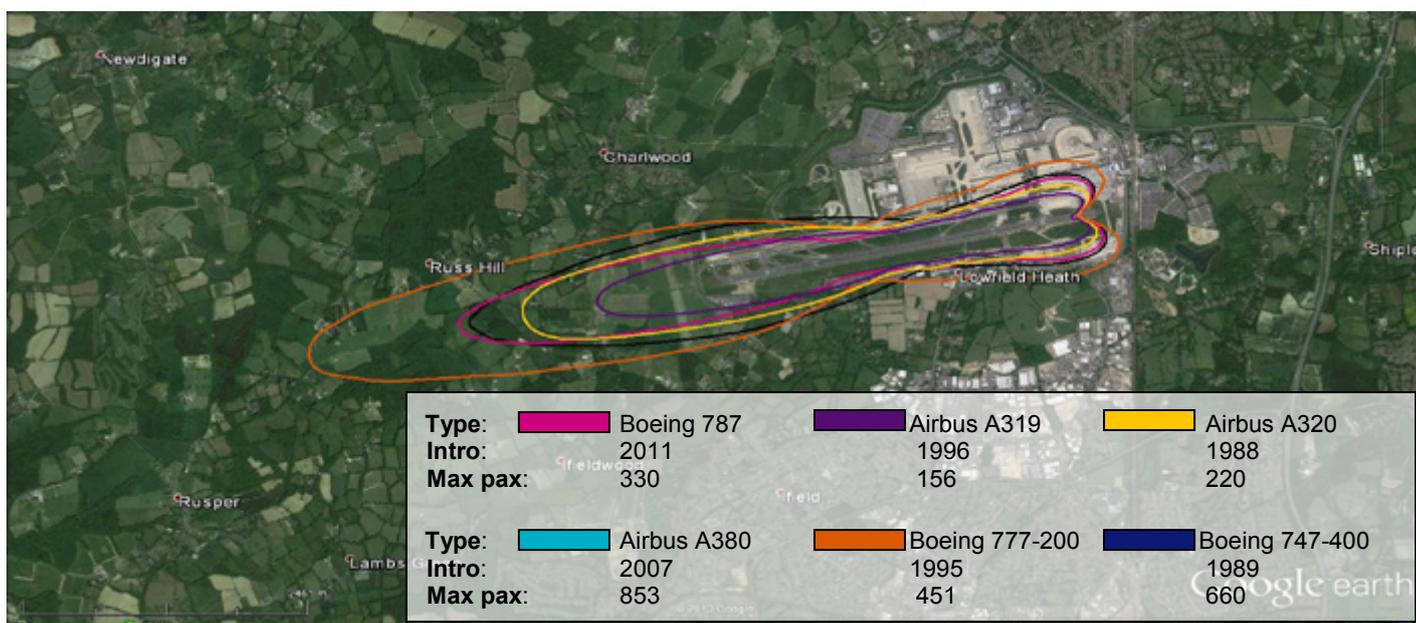


Figure 4.2: Gatwick departure 90 dBA SEL contours on 26 SAM for selected aircraft



Despite the impact of the 2008 financial crisis and subsequent recession on passenger demand (and flight numbers at most airports), noise improvements over the past decade have been slower than in previous years. In part this is because following the retirement of the Concorde by both Air France and British Airways, the number of flights by extremely noisy, older aircraft from the 1960s and 1970s reduced to close to zero at Heathrow and many other UK airports. It may also be in part because the post-9/11 and financial crisis downturns, combined with the cyclical nature of airline fleet renewal and type introduction mean there hasn't been a significant number of new aircraft operating during the period, and in part because there are fewer potential improvements in noise performance through manufacture following the step changes in performance over the previous 40 years. At Heathrow due to tightening capacity constraints, there has also been a steady increase in aircraft size, the proportion of long haul flights has increased, and many domestic routes have reduced frequency or disappeared; all of which would have seen noise increasing without the accompanying technological and operational developments.

Today's technology

Airbus A380

The Airbus A380 entered service in October 2007 operated by Singapore Airlines, and began flying into Heathrow in March 2008. In a typical configuration, it is capable of carrying around 525 passengers. If operated as a fully economy class service, it would be able to carry over 850 people. The A380 is one of the quietest wide-body jet aircraft currently in operation, with only the newer and significantly smaller Boeing 787 being quieter. Throughout its design, there was a conscious focus on reducing noise, and ensuring that it was able to meet ICAO's Chapter 4 Standard adopted in 2001 and implemented in 2006.

The focus on noise performance was in part to ensure that delayed departures could still operate during the night period at Heathrow Airport, where the Quota Count (QC) system imposes much stricter controls for night-time operations than ICAO's Chapter 4 standard, limiting operations for any aircraft with a QC/2 rating or higher from being scheduled between 2300 and 0600¹⁸.

¹⁸ http://www.heathrowairport.com/static/Heathrow_Noise/Downloads/PDF/Nightflights11.pdf

The A380 is rated as 2 for departure and 0.5 for arrival noise, allowing its use within the total night period. By contrast, the 747-400 is rated as QC 4 for departure and QC 2 for arrival, meaning it is prohibited from being scheduled to depart from Heathrow after 2300 and before 0700, though it may operate as a delayed departure. The newer Boeing 747-8 model falls within the applicable QC limits.

Figure 4.3 illustrates the Airbus A380 landing noise footprint compared with that of the Boeing 747-400, the principle aircraft it is replacing at London Heathrow airport. Whilst reducing noise, the A380 also increases the number of seats available by approximately 26 percent.

Figure 4.3: Heathrow arrival 85 and 90 dBA SEL contours for an Airbus A380 landing 27L compared with a Boeing 747-400, the principle aircraft it is replacing



To put the A380's size and noise performance within its historical context, in a typical configuration, the aircraft allows for a seat capacity increase of 90% over 1992's A340-300, for no additional noise.

This step change underlines the potential for quota-based incentives to drive airline and manufacturer action to improve noise performance. Upon its introduction at Heathrow in 2008, operated by Singapore Airlines, the airline, airport, and NATS jointly trialled and implemented new departure procedures to reduce fuel burn and CO₂ emissions while remaining within noise limits - highlighting the potential for noise to be managed within strict limits on other environmental impacts.

Boeing 787 Dreamliner

Although they were developed at a similar time, and introduced to service within five years of one another, the Airbus A380 and Boeing 787 Dreamliner are quite different types of aircraft. While the A380 is capable of carrying over 800 passengers, the 787 has a more traditional maximum passenger configuration of 330 people. The 787 is the world's first composite commercial transport aircraft, and was designed to achieve fuel savings of up to 20% over the Boeing 767 which it replaces.

Like the A380, the 787 also operates within Heathrow's strict Quota Count operational restrictions for night-time flying, and is quieter than the aircraft types it aims to replace.

Airbus A350

In 2004 Airbus began a programme of work to create a new wide-body aircraft capable of longer flights and with a similar capacity to the 787. This has grown into the A350 XWB (extra wide body), a twin-engined aircraft carrying between 250 and 350 passengers depending on configuration. It is expected to begin commercial operations during 2014. Like the 787 it features a composite airframe, and is designed to be very fuel efficient. As with other new types, noise performance is promised to significantly improve over existing wide-body aircraft, but data is not yet available to quantify the gains.

Improving existing types

Introducing new aircraft types is a slow and typically cyclical process that can be fraught with delays and issues, as recent experience with the introduction of both Airbus and Boeing's new models, the A380 and 787, has shown. Even when new aircraft types are available, refueling is a lengthy and expensive process for airlines, with significant resource impacts. In addition, despite the existing incentives to improve fleet noise performance, even at Heathrow, there has been no evidence that airlines have changed their normal fleet replacement cycles (for instance, in early 2014, British Airways' long-haul fleet consisted of four Airbus A380s, 55 Boeing 747-400s, 21 Boeing 767-300s and 55 Boeing 777s covering an age range of 0 to 25 years). Opportunities to better incentivise both based and non-based airlines to enhance fleet noise performance are explored in Chapter 7.

The introduction of newer models of existing types does offer the potential for improving noise (and other environmental and efficiency) performance, which, while still representing a significant outlay for airlines, reduces some of the costs and risks associated with purchasing brand new aircraft types.

To put that in context, the latest version of Boeing's 747, the 747-8 Intercontinental, introduced in 2005, claims a 30%¹⁹ noise performance improvement over that of its predecessor the 747-400, originally introduced in 1989.

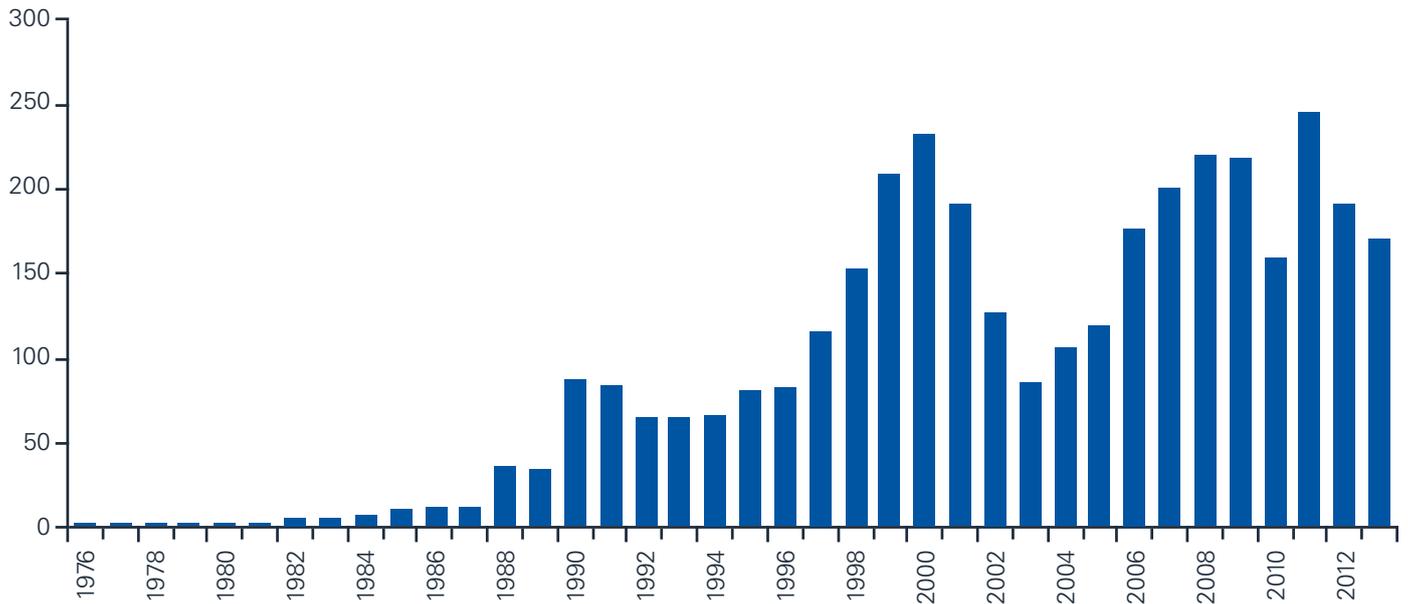
The future?

Given the significant improvements in performance in the latest types of aircraft, and the general trend of slowing noise contour reduction over the past decade, in future when new types are introduced, the noise improvements may not be as significant as with previous generations of aircraft. In this context, we welcome industry's ambition to drive further improvements, set out for instance in the [Flightpath 2050 vision](#)²⁰.

Assuming a standard fleet life of 25 years, in line with usual depreciation assumptions, and take the last generation of aircraft as being purchased up until 2013 (which does not factor in continuing purchases of older aircraft by both legacy and low cost carriers), we can expect to see significant noise improvements arising from normal fleet renewal exercises as airlines switch from older types to the latest aircraft until at least 2038. To provide context, figure 4.3 shows the ages of the fleet in operation at Heathrow during 2013 - significant numbers of aircraft pre-dating the latest generation are still in operation, showing the potential for normal fleet renewal to improve noise performance.

¹⁹ Relative to the Boeing 747-400F based on an 85dBA contour.

²⁰ Available here: <http://ec.europa.eu/transport/modes/air/doc/flightpath2050.pdf>

Figure 4.3: LHR Aircraft fleet 2013 - No. aircraft vs. year built

Source: ERCD data

In addition, as cities become more populated, and assuming continued global growth in air travel demand, pressure will continue for manufacturers to introduce improvements as they update their models, even without introducing entirely new types, meaning airlines should see noise impact falling as they replace older aircraft, whether with new types or updated models. The way these pressures incentivise airlines to demand fleet improvements from manufacturers is explored in Chapter 7.

Concerns in relation to climate change, carbon dioxide emissions, and local air quality could also have an impact on noise performance. Although there is not a direct correlation, and noise performance has previously been reduced alongside emissions reductions, as gains become more marginal in future, the potential requirement to trade off emissions and noise performance is likely to increase. In adopting a new aircraft noise standard to come into effect in 2017, ICAO recognised the need to provide room for future low-carbon technologies²¹, such as a wider range of propeller-engined aircraft. The Sustainable Aviation Noise Roadmap²² for example, highlights that there are two conceivable paths for future aircraft design, low-carbon designs and low-noise designs. Whilst low-carbon designs may be quieter than existing aircraft, they may not be as quiet as low noise designs.

²¹ Report of the Ninth Meeting of the Committee on Aviation Environmental Protection, ICAO Doc. 10012, Montreal, 4-15 February 2013.

²² Reference SA Noise Roadmap.

Policy-makers should be aware of this when considering incentives around sustainability and ensure that perverse incentives are not introduced which lead to increasing noise impacting local residents.

Historically, as GDP and living standards have increased, so has people's desire for a quiet, relaxed home environment, and a tranquil setting out of doors. This may have contributed to changes in attitudes to aircraft noise in some countries, although there is no robust evidence for this in the UK. However, as quality of life continues to improve it is reasonable to assume that people's expectations will continue to increase, potentially implying a need for industry to continue to improve noise performance simply to stand still in terms of public perception.

That is why alongside continued efforts to lower noise through manufacturing, the airline industry must do more to use the aircraft they purchase in the most noise-neutral fashion, safely, and the aviation industry as a whole must accept that more can be done to fund mitigation of remaining impacts.

These concepts are explored in the subsequent chapters.



CHAPTER 5

Operate: Limiting noise through operational approaches

Operational improvements form one of the four elements of the ICAO balanced approach to noise management. They cover a wide variety of techniques, but can be grouped into four areas:

- Operational measures that reduce the amount of noise emitted.
- Operational measures that increase the distance between the aircraft source of noise and the ground.
- Operational measures to cause noise to effect less populated areas.
- Operational measures that provide respite from aircraft noise

Depending on how the measure is applied, it may achieve one or more of the above. Additionally, operational measures may also result in cumulative improvements. Measures tend to be specific to either take-off or landing and are summarised separately below.



Departure

Noise abatement departure procedures

On departure, flight crew's primary aim is to accelerate the aircraft to take-off speed, and after take-off to climb rapidly. At or above 800ft altitude (the minimum altitude defined by ICAO), engine power may be reduced in order to preserve an adequate service life for the engines, and to reduce noise. Also at or above 800ft altitude, the aircraft may be accelerated from the take-off speed. Engine power is therefore used to gain both altitude and speed.

The balance between how much energy is put into gaining altitude and speed, and at what altitudes power reduction and acceleration are initiated, and in what order, are set out in an airline's noise abatement departure procedure(s), that are incorporated into its standard operating procedures. These procedures are heavily regulated to ensure that a proliferation of procedures does not lead to confusion and impact on safety levels. ICAO guidance recommends that an airline adopts no more than two procedures for any given aircraft type. This requirement is made mandatory within EU regulations.

One procedure does not necessarily have a better noise impact than another. Instead, changing from one to another procedure may redistribute noise from one location to another, resulting both noise decreases and noise increases, as illustrated in Figures 5.1 and 5.2.

Figure 5.1: Re-distribution of noise associated with a change from an example noise abatement departure procedure to another

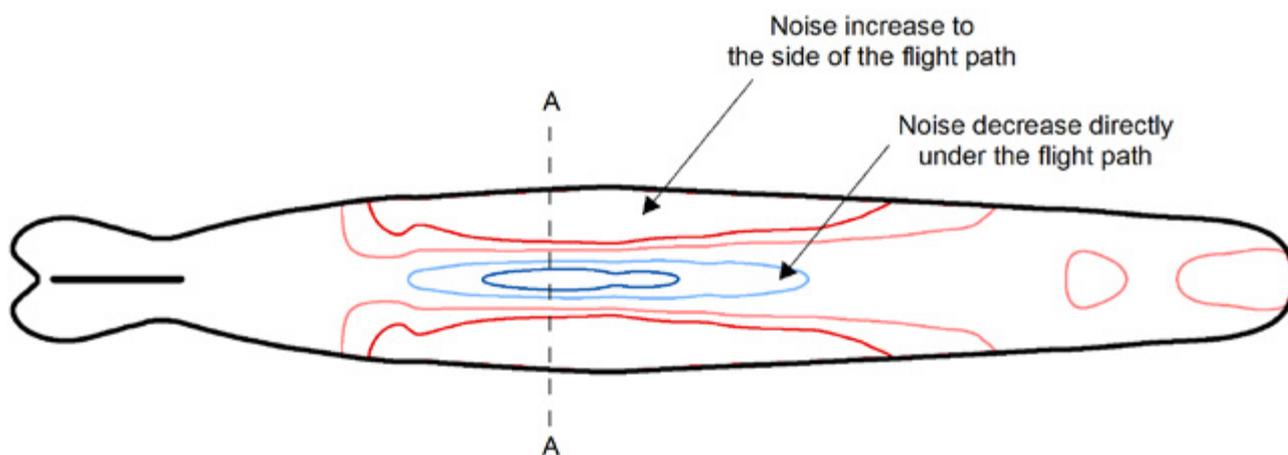
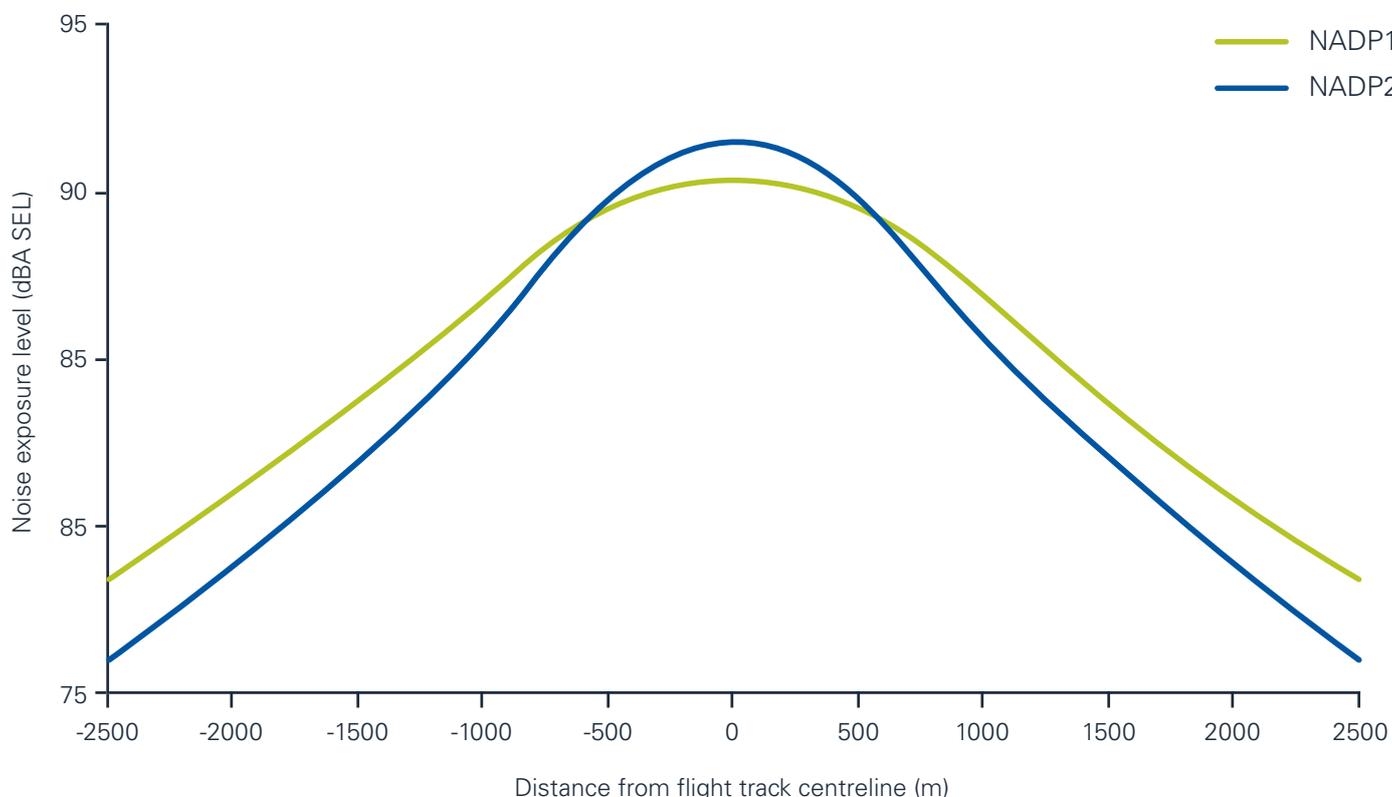


Figure 5.2: Cross-section A-A (as above Figure 5.1) showing noise change under and to the side of the flight path



Airlines tend to adopt noise abatement departure procedures that are compatible with their dominant base of operation, e.g. their central hub airport. Some airports direct airlines to use preferred procedures, though they have no formal power to enforce this, and in isolated cases it could cause an airline to breach EU regulations if the procedure directed by the airport was not one of the two adopted by the airline on a given aircraft type.

Although noise abatement departure procedures affect how noise is distributed for aircraft altitudes between 800 to 4,000ft, the procedure selected can also affect how efficiently an aircraft climbs to cruise altitude, and thus affect the overall fuel used for a flight. The effect is greatest for short-haul flights, where the climb phase is a greater proportion of overall fuel used, but even then the fuel change is seldom more than 1%. For long-haul aircraft, whilst the difference between two procedures may be larger in absolute terms, it typically amounts to less than 0.5% of the overall fuel used for a flight.

Increased take-off power

Modern aircraft seldom require the full runway length in order to take-off from an airport. Airlines, often driven through incentives in engine maintenance contracts, routinely reduce the amount of power used for take-off to minimum safe levels. This has the effect of delaying lift-off from the runway and reducing climb gradient up to the point at which engine power is reduced to climb power. In some cases climb power is also reduced, further lowering the aircraft's rate of climb more distant from the airport.

Whilst increasing take-off power increases the amount of noise being emitted by the engines, this is often offset by the increased rate of climb, resulting in a net reduction in noise directly beneath the flight path. This reduction comes at a price. Noise levels will tend to increase prior to take-off, though much of this will occur with an airport's boundary. Secondly, the increased altitude achieved, whilst reducing noise directly beneath the flight path, can increase noise to the side of the flight path, depending on the specific characteristics of the engine.

Increased take-off power dramatically increases engine wear and also engine emissions of oxides of nitrogen (NO_x), a major component of which (nitrogen dioxide (NO₂)), impacts on air quality and is thus regulated through EU Air Quality Directive that limits NO₂ concentrations. NO₂ concentrations exceed EU limits at several locations in the vicinity of Heathrow, though the greatest contribution comes from road traffic emissions. The CAA is engaged with the DfT and other stakeholders to better understand trade-offs between increasing take-off power, noise and local air quality and consider what, if any role, increased take-off power could play in mitigating noise exposure.

Increased take-off power increases rate of climb and acceleration, resulting in a marginal reduction in fuel burn, contrary to expectations. This occurs because aircraft fuel efficiency increases with increasing altitude and speed.

Arrival

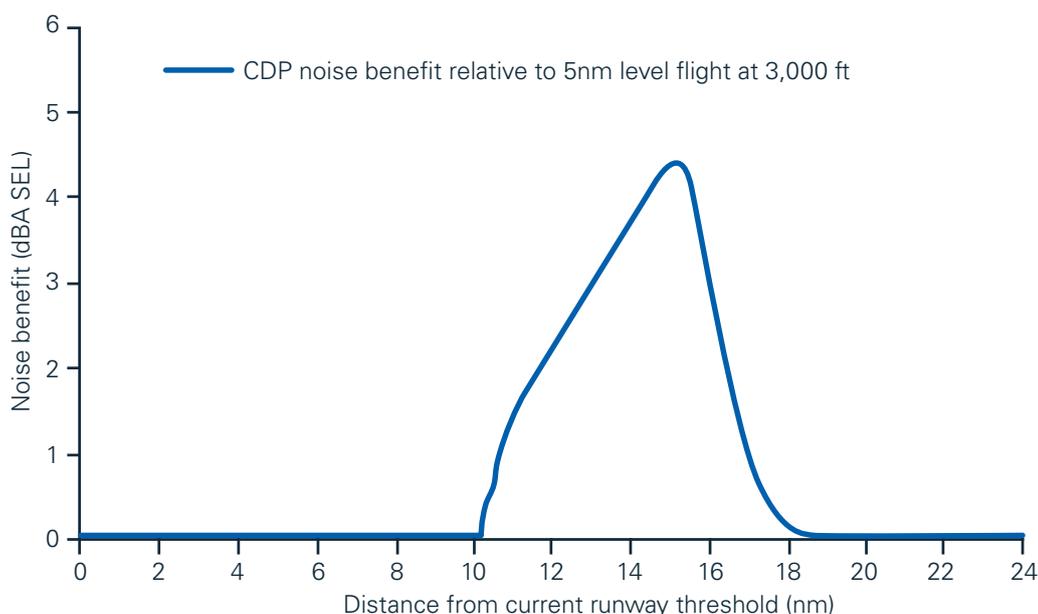
The aviation industry has long focussed on reducing departure noise, as given the increased power necessary to achieve take off, noise impact is greater, though affecting a more concentrated area. In recent years, increased focus has been turned towards arrival noise as industry and policy-makers have looked to tackle its impact on communities over a larger area.

Continuous Descent Operation

In order to set aircraft up for approach to landing, Air Traffic Control descend aircraft and reduce their speed. The optimal trajectory giving minimum noise and minimum fuel burn is what is known as a Continuous Descent Operation (CDO). In the UK, a CDO is defined as having no more than 2.5nm of level flight below 5,500ft altitude above airfield (aal).

At 5,500ft aal and below, the optimal trajectory is a 3 degree descent to touchdown. Because the noise benefit of a CDO will vary depending on the altitude and length of level flight associated with a non-CDO, it simpler to express the noise dis-benefit of a non-CDO relative to a perfect CDO. Previous analysis has shown that the typical non-CDO has 5nm of level flight at altitudes from 3,000 to 6,000ft. Compared to a perfect CDO, this results in noise increases of up to 2.5 to 5dB, varying over distances from touchdown of 10 to 25nm (Figure 5.3).

Figure 5.3: Noise benefit of Continuous Descent Operation



Source: ERCD data

CDO performance is reported by a number of UK airports. In 2013 daytime CDO performance at London Heathrow was 84 percent²³. At London Gatwick in 2012 it was 89 percent²⁴. At night, rates are higher, typically around 94-95 percent.

It is difficult to benchmark UK airport CDO performance against other international airports as there is no internationally agreed standard for monitoring CDO performance and secondly, airspace and operational arrangements sometimes preclude the use of CDO, e.g. due to the use of independent parallel runway arrival operations. Using similar criteria to UK airports, Helsinki airport reported their 2013 daytime CDO performance was 60 percent²⁵. During the night period, 2200-0530, Amsterdam Schiphol requires the mandatory use of precision RNAV arrival procedures to facilitate low-noise continuous descent operations²⁶.

Some airports publish league tables that compare their airline customers' performance across a series of noise mitigation measures (for instance Heathrow's Fly Quiet League tables²⁷). Such tables provide an incentive for airlines to improve their performance, help airports to target their attention where most benefits can be made, and help to inform third parties which airlines are failing to manage noise.

We recommend airports consider the potential for such league tables to add value in their efforts to reduce noise, and consider other measures to ensure airlines adopt CDOs.

Low power/low drag

As an aircraft reduces speed during the intermediate approach phase, flaps and landing gear are deployed to maintain lift and to prepare the aircraft for landing. For a given aircraft type and mass, each flap setting has a minimum safe flight speed. Landing gear is typically deployed at a specific altitude, though for some aircraft its deployment can also be linked to a flap setting.

23 Available from http://www.heathrowairport.com/static/Heathrow_Noise/Downloads/PDF/Flight-Performance-Report-2013.pdf

24 Available from http://www.gatwickairport.com/PublicationFiles/business_and_community/all_public_publications/aircraft_noise/GatwickFPT2012_final.pdf

25 Available from http://finaviareports.studio.finavia.fi/file/dl/i/OpxMEQ/7A9Ac8WreFaT_bhMVtFl6g/Finavia-Annual-Report-2013.pdf

26 AIP Netherlands (2013), EHAM AD 2.21 Noise Abatement Procedures, section 3.

27 Available from <http://www.heathrowairport.com/noise/what-we-do-about-it/flyquiet-programme>



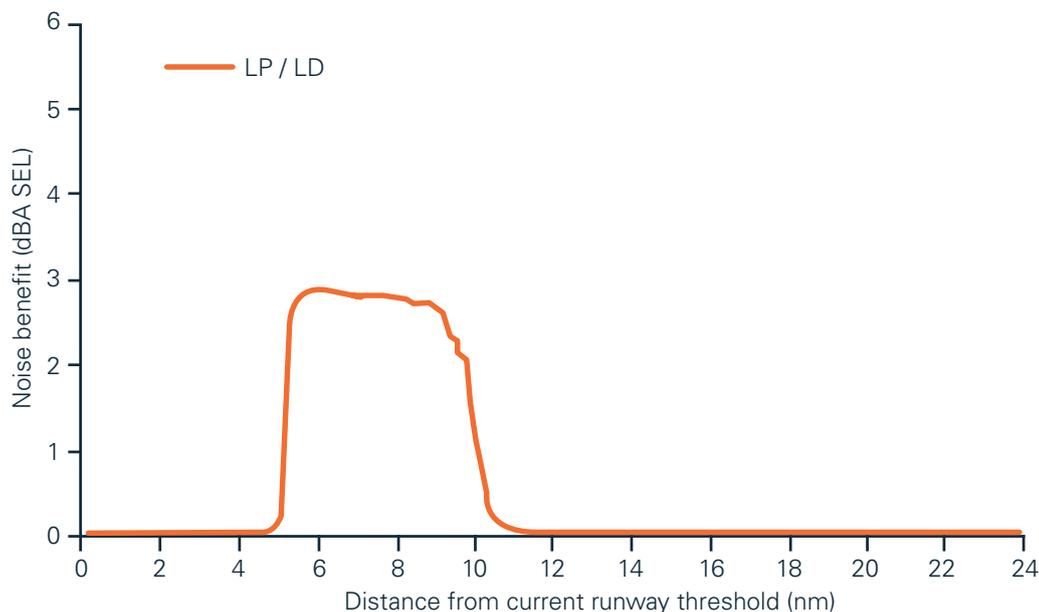
Low power/low drag is the collective term used for describing the lowest noise configuration for a given speed and/or altitude during the approach.

Selecting more flap than is required for a given speed will typically lead to more airframe noise, higher engine power due to greater drag and thus higher noise. The effect is, however, small, no more than 1 dB.

In contrast deployment of the landing gear, significantly increases aircraft drag and airframe noise, increases engine power and thus also engine noise. The combined effect may be as much as 5 dB.

There is no established optimal point to deploy landing gear, instead international guidance to airlines specifies that the aircraft should be in the landing configuration (landing gear deployed and landing flap selected) no later than 5 nm, 1,500ft aal, in order to prevent late deployment. This is to ensure a safe stabilised approach is achieved.

Historically, limited attention has been given to landing gear deployment. However, recent CAA analysis suggests that 90 percent of arrivals did not have landing gear deployed at least 8 nm from touchdown, falling to 73 percent at 6nm. Noise measurements indicate that early landing gear deployment increase noise by 3-5 dB, enough to make the latest generation of aircraft noisier than the generation they replaced (Figure 5.4). Airports should consider measures to incentivise airlines to deploy landing gear at the appropriate point to balance operational and safety requirements and noise reduction.

Figure 5.4: Noise benefit of good-practice landing gear deployment

Reduced landing flap

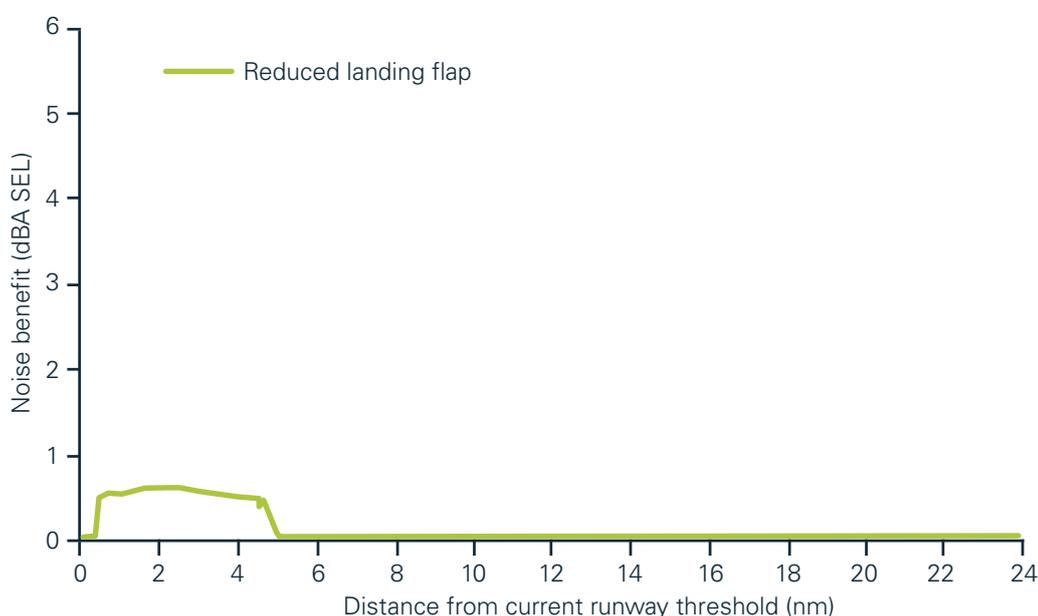
Most aircraft are certificated with two landing flap settings. The first is a full landing setting, which sets the flaps at their maximum angle, also producing their maximum drag. The reduced landing flap setting reduces the angle, also reducing drag and thereby requiring less engine power and resulting in less noise being emitted.

Reduced landing flap increases landing speed, which can lead to increased brake wear and/or increased runway occupancy time. However, it also reduces fuel burn and engine emissions, and for some aircraft, it reduces stress on the flap system leading to maintenance savings. As a consequence, reduced landing flap is a widely adopted technique by many operators and some airports specify it in their noise abatement procedures²⁸.

²⁸ AIP Japan (2013), RJAA (Tokyo Narita) AD 2.21 Noise Abatement Procedures.

Reduced landing flap typically results in noise reductions of 0.5 to 1.5 dB (see Figure 5.5), the larger figure typically being associated with older aircraft types. Since the landing flap is adopted just after the landing gear is deployed, it is typically selected at heights of 1,200 to 1,500 ft, i.e. 4 to 5 nm from touchdown. As such reduced landing flap reduces noise very close to landing. Although a number of operators already use this technique, such a measure could be adopted relatively quickly by others to enhance noise benefits. Airports should work with their operators to enhance adoption of reduced landing flap.

Figure 5.5: Noise benefit of reduced landing flap



Although a number of operators already utilise the reduced landing flap technique, such a measure could be adopted relatively quickly by others to enhance noise benefits. Airports should work with their operators to enhance adoption of reduced landing flap.

Displaced landing thresholds

One method of mitigating the impact of aircraft noise is the displacement of airport runway thresholds from the extremity of the runway surface end to a location further down the runway. Displacing runway thresholds allow aircraft to fly at higher altitudes as they pass over communities located near the airport, thereby increasing the distance between aircraft producing noise and thus lowering noise on the ground. Runway thresholds have been displaced for many years to increase the clearance between approaching aircraft and obstacles located near the airport.

Tokyo Narita airport features a 750 m displaced threshold to its 4,000 m main runway 34L²⁹.

The International Civil Aviation Organisation (ICAO) prescribes the following criteria:

“The practice of using a displaced runway threshold as a noise abatement measure shall not be employed unless aircraft noise is significantly reduced by such use and the runway length remaining is safe and sufficient for all operational requirements.” (ICAO Doc 8168, Part I, Section 7, Chapter 3, Page 4, Subsection 3.6).

Because assessments against the ICAO criteria are very site-specific, evaluation should be done on a case-by-case basis, and any airport considering the use of displaced runway thresholds as a noise abatement procedure would need to conduct a similar analysis under the ICAO criteria, but such analysis must be based on the specific conditions associated with that airport. A displaced threshold whilst providing noise benefits, could have potential impacts on capacity, operational resilience, air quality and of course its cost effectiveness would need to be considered against alternative measures.

We will work with industry to gain a better understanding on the issues associated with displaced landing thresholds and will engage with industry, government and the Airports Commission to move forward operational assessment of the potential benefits.

Slightly steeper approach

The international standard Instrument Landing System (ILS) glide path angle is 3 degrees. Increasing an aircraft’s glide path reduces noise in two ways.

Firstly, it increases the height of the aircraft over the ground, increasing the distance over which sound travels before it reaches a population.

Secondly, it increases an aircraft’s rate of descent, reducing the amount of engine power required, reducing the amount of noise emitted.

²⁹ AIP Japan (2013), RJAA (Tokyo Narita) AD 2-5 Aerodrome Chart.

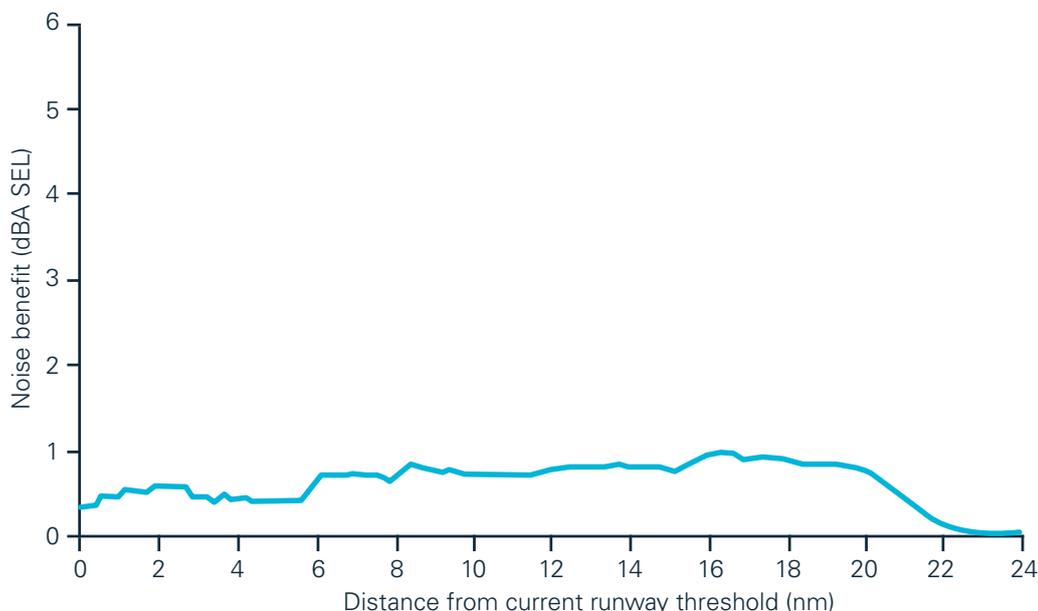
Some airports in the UK already utilise glide path angles greater than 3 degrees to account for obstacles preventing the standard 3 degree flight path being adopted. Category III ILS systems that provide the highest capability to land in poor visibility are limited to angles of 3.25 degrees. Above 3.49 degrees ILS are limited to CAT I, offering less capability than CAT II or CAT III systems.

For most airports, the ability to continue operations in low-visibility condition is a key requirement that would dissuade it from adopting approach angles of greater than 3.25 degrees. In addition, ICAO currently urges States not to adopted flight path angles greater than 3 degrees for environmental reasons.

Frankfurt airport's new runway, 07L-25R is required to have two ILS to enhance operational resilience. Since the existing ILS was already CAT III, the airport in addition installed a CAT I system at 3.2 degrees. Both systems operate simultaneously. In low-visibility operations, the CAT III 3 degree system is used, however, when conditions are appropriate, aircraft are directed to use the 3.2 degree system.

The benefits of an increase in glide path angle to 3.2 degrees are illustrated Figure 5.7.

Figure 5.7: Noise benefits of an increase in glide path angle to 3.2 degrees



It is clear that the additional benefits of 3.2 degree approaches are relatively small, though it must be recognised that this procedure is not used at any airport (except where obstacles dictate) so benefits could accrue across a large proportion of operations at many airports (excluding operations in low-visibility).

However, it is likely that even 3.2 degrees could interfere with the ability to use low power/low drag and reduced landing flap techniques. It is therefore recommended that industry consider the potential for slightly steeper approaches to impact on existing practices such as low-power/low-drag and reduced landing flap techniques as part of consideration of adopting this procedure where appropriate to mitigate noise.

The aviation industry should consider the potential for slightly steeper and reduced landing flap techniques as part of consideration of adopting this procedure where appropriate to mitigate noise.

Two-segment approach

Because of the issues highlighted above in relation to the use of a slightly steeper approach all the way to touchdown, an alternative concept referred to as the two-segment approach is being actively considered as an alternative means to reduce arrival noise.

A two-segment approach adopts a much an intermediate approach phase flown at a steeper angle, before transitioning back to a standard 3 degree approach. This would potentially provide noise benefits further out during the approach phase, without affecting the final approach phase.

During the past twelve months British Airways has provided flight simulator access and worked with the CAA to address and consider issues associated with the concept, including:

- Technical feasibility – can such a procedure be flown safely by all types?
- Environmental benefits – what is the magnitude of the benefits achievable whilst ensuring operations remain safe?
- Airport capacity impact – what impact might it have on airport capacity?
- Scalability – could it be deployed only at certain times of day and what might the training and oversight requirements be?

The CAA recognises the need for industry engagement to address these issues and welcomes British Airways' commitment and resources to research this concept.

Because of the much greater uncertainty and lack of maturity associated with the concept, it is not possible to illustrate potential noise benefits at this time.

However, the fact that during the steep intermediate segment, an aircraft would be higher and at lower power than during a slightly steeper approach, the noise benefits would be expected to be greater than for a slightly steeper approach.

The CAA will continue to focus on exploring the potential for two-segment approaches, and seek aviation industry support in order to realise the potential for this concept to significantly reduce approach noise.

Arrival summary

Many of the operational arrival noise mitigation measures considered are complimentary, in that they provide noise benefits at different distances from landing and can be utilised as part of a coherent operational policy, as summarised below and illustrated in Figure 5.8 and in cumulative form in Figure 5.9:

Distance from runway threshold	Procedure / technique
0 to 5 nautical miles	Reduced landing flap
5 to 10 nautical miles	Low power/low drag
10 to 20 nautical miles	CDO

Figure 5.8: Comparison of the benefit of individual arrival noise measures

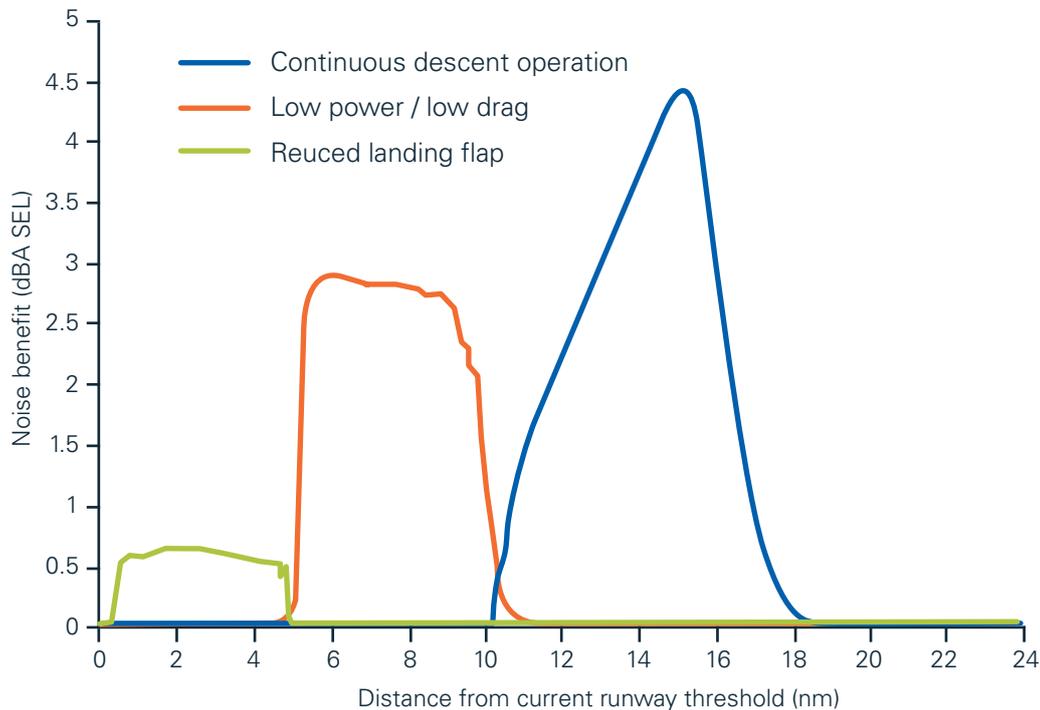
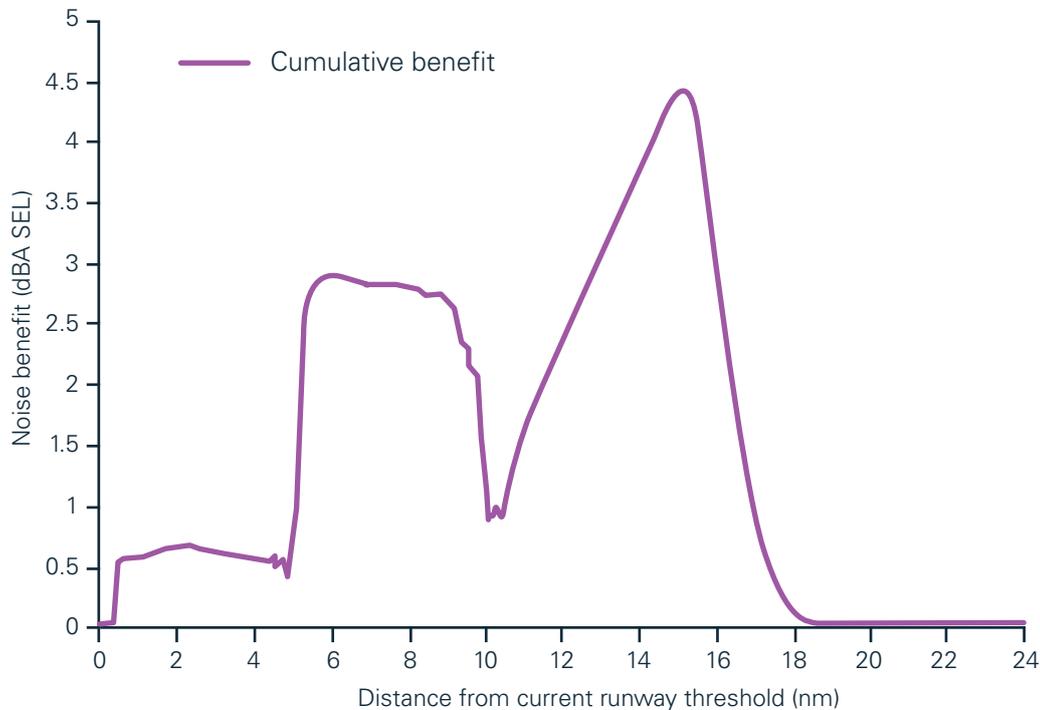


Figure 5.9: Cumulative arrival noise benefit (including 800m displaced threshold)



In the context that the approach noise benefits of the latest generation of aircraft typically offer noise benefits of ~3 dB, cumulative operational benefits are significant.

The converse is also true; Figure 5.8 can be interpreted as the noise increase for a poorly flown approach, effectively cancelling out the noise improvements provided by the design and manufacture of a modern aircraft. Industry is therefore urged to ensure optimised procedures are adopted across new and older aircraft types.

Optimised lateral path

The preceding sections have considered optimising of the vertical flight profile, to reduce noise emission and/or increase the distance between the noise source and the ground, thereby reducing noise exposure on the ground.

Optimising the lateral flight path taken by arriving and departing aircraft, does not reduce aircraft noise, instead it redistributes it. Depending on the local population distribution it may be possible to achieve a net reduction in the number of people exposed to certain levels of noise by changing the lateral path, however, this net benefit may result in noise exposure increases for some.

Historically the ability to provide optimised lateral paths was limited by the need to navigate using ground-based navigational aids. The transition towards Performance Based Navigation (PBN) and Area Navigation (RNAV), provides an opportunity to improve navigational accuracy, so that aircraft follow more precise flight paths resulting in more precise track keeping. PBN and RNAV also offer the potential to tailor arrival and departure routes to avoid more densely populated areas and therefore reduce the number of people impacted by aircraft noise.

The CAA will continue to engage with industry through the Airspace Change Process and the Future Airspace Strategy programme to identify opportunities for optimised lateral paths to deliver noise benefits.

CHAPTER 6

Mitigate: Reducing noise on the ground

Whilst the preceding chapter discussed ways in which noise impact may be reduced or re-distributed, this chapter considers how the remaining impacts may be mitigated through ground-based measures.

Noise insulation

One of the more common ways of mitigating aircraft noise impacts is to insulate residential properties and noise sensitive buildings, e.g. schools and hospitals. Noise transmission from outside to inside is a complex process being dependent on wall, window frame and window glass construction and type. However, the greatest sound transmission, particularly for a British brick or stone built house, is generally considered to occur through the windows.

Research conducted by Napier University for Defra³⁰ found that a range of partially open windows reduced outdoor aircraft noise by 14 to 19 dB. This finding is further supported by the WHO figure of 15 dB. A closed single glazed window typically reduces transmission by a further 5-10 dB, i.e. a total reduction of 20-25 dB. Adding secondary glazing with a large air gap can reduce sound transmission by an additional 10-15 dB, resulting in a total reduction of 30-40 dB. At this point, sound transmission through windows may no longer be the limiting factor, at which point insulation of walls or loft or roof spaces can sometimes prove effective in combination with secondary glazing.

An issue that consistently occurs with secondary glazing, is that if a window is opened, the benefits of the additional insulation are lost (as illustrated above). This is sometimes cited as a reason not to rely on noise insulation to address noise exposure, particularly in the case of airport expansion. There are, however, solutions to the windows open issue in the form of forced ventilation. This, however, adds significant additional cost and also incurs on-going running and maintenance costs.

³⁰ NANR116: Open/closed window research: Sound Insulation through ventilated domestic windows, Building Performance Centre, Napier University, April 2007.

Eligibility criteria

In some countries noise insulation can take the form of a pre-defined package, e.g. addition of secondary glazing. In other countries it is based around the achievement of target interior noise levels, the package of insulation measures then vary depending on the specific level of insulation required. In extreme circumstances, it can include sealed triple glazing with forced ventilation, and wall and roof space insulation. Costs can therefore vary significantly, dependent on the strategy adopted.

The US has adopted a statutory aircraft noise insulation programme that aims to insulate all housing within the 65 dB DNL³¹ noise contour around each airport. The Chicago O'Hare Residential Sound Insulation Programme is the largest of its kind in the country, insulating to date almost 10,000 homes.³²

In France, there is a statutory scheme to insulate all housing within the 55 dB L_{den} contour. At Amsterdam Schiphol, over 13,000 dwellings have been insulated since 1980 in three phases. A fourth phase is currently being considered.

Within the UK, Heathrow and Gatwick airports are designated for the purpose of section 79 of the Civil Aviation Act 1982, which enables the Secretary of State to make a noise insulation scheme for relevant buildings near the airport. There have been several statutory schemes at these airports but none is extant, as most airports have brought forward voluntary schemes, often in collaboration with government. As a result there is a wide variation in eligibility criteria. Some airports provide separate day and night insulation schemes, whilst others define one scheme based on multiple criteria.

London Heathrow currently has a residential day scheme based on the 1994 69 dB L_{eq} , 18h contour and a night scheme based on the 90 dB SEL noise footprint of the noisiest aircraft operating at night, as recommended by government. The night scheme is eligible to just over 40,000 dwellings, however uptake has been very low due to a funding contribution of 50% and perceived high costs of the single supplier.

31 There is no precise relationship between DNL and L_{eq} , 16h, however, comparisons at London Heathrow show that L_{eq} , 16h is approximately 2dB less than the DNL at a given location. Thus a 65 dB DNL contour is equivalent to a 63dB L_{eq} , 16h contour.

32 http://www.oharenoise.org/residential_program.htm

At Stansted airport, a single voluntary scheme is in place, which incorporate separate day, night and ground noise criteria into a single eligibility criteria, in order to take into account differences in airport use between day and night that affect noise exposure. The day noise exposure criterion is based on the 66dB L_{eq} , 16h contour. For night time, the 57 dB L_{eq} , 8h contour is used, however in addition the 90 dB SEL footprint for composite worst aircraft scheduled on each route is also used, reflecting noise from a single operation³³.

London City airport has a daytime noise insulation scheme based on the 57dB L_{eq} , 16h noise contour, a lower daytime level than any other UK airport.

Funding

Funding support and eligibility for noise insulation varies considerably between countries and even between airports in the same country. Some countries have adopted statutory schemes that apply nationwide and are fully funded through levies on passenger tickets or noise related charges/taxes on each flight.

The US FAA Passenger Facility Charge (PFC) Programme allows the collection of PFC fees up to \$4.50 for every boarded passenger at commercial airports controlled by public agencies. Airports use these fees to fund FAA-approved projects that enhance safety, security, or capacity; reduce noise; or increase air carrier competition. In March 2014, the FAA reported that fiscal year PFC revenue was \$2.8 billion and that noise insulation projects received 3.5% of total PFC revenue or \$99 million for noise insulation of residential and public buildings. The Chicago O'Hare residential sound insulation programme has so spent over \$550 million insulating almost 10,000 dwellings and over 120 schools.

The French statutory system is funded through a noise tax on each departure, introduced on the 1st January 2005³⁴. Based on typical secondary glazing costs (in the UK), it is estimated that it will cost around £1 billion to complete the Paris Charles de Gaulle noise insulation scheme.

33 ERCD Report 0304, Stansted Airport: A Study of Aircraft Noise Insulation Boundaries, DJ Monkman et al, Civil Aviation Authority, July 2003.

34 https://www.formulaires.modernisation.gouv.fr/gf/getNotice.do?cerfaNotice=51058%2307&cerfaFormulaire=12503*07

At UK airports, support schemes typically offer funding support of 50%, though some airports have consulted on varying the funding contribution depending on the noise exposure level, within the overall eligibility criteria.

Airports should assess their insulation schemes within the context of their individual circumstances, but when insulation funding is offered, it is most effective where funding is available in full for those most seriously impacted by noise. It is also sensible to allow eligible households to source their own supplier, allowing market forces to drive down overall costs. Where part funding is available, the proportion funded by the airport should depend on the level of noise impact – with more funding offered to those who experience greatest noise.

Property removal

The US FAA PFC Programme is also used to fund the purchase of land in order to reduce noise impacts. Critics often argue that sanitising land around airports is not viable, however, in the US the purchased land is not sanitised, but re-designated and used for less sensitive purposes, e.g. commercial use. In FY2013 \$25 million of PFC revenue was used for noise compatible land purchase.

Historically, population density in the south east of England has been considered too high for the removal of property to be considered a viable prospect. However, despite similarly high population densities, in the Netherlands, Amsterdam Schiphol airport has implemented a dwelling removal zone based on the 71 dB L_{den} noise contour. Residents are relocated to dwellings with a lower noise exposure, thereby protecting people from the very highest noise exposures.

Whilst policies to remove property experiencing very high noise levels are long standing and often on based on judgement, there is increasing evidence, though with considerable uncertainty that very high noise exposures can result in acute health impacts, such as heart attacks. Research, such as that by Babisch^{35,36}, indicates that relative risk of heart attack increases above 55 dB L_{den} .

35 Babisch, W, "Transportation Noise and Cardiovascular Risk: Review and Synthesis of Epidemiological Studies, Dose-effect Curve and Risk Estimation". Federal Environmental Agency (UBA) Report, 2006.

36 Babisch, W, "Exposure-Response Curves of the Association Between Transportation Noise and Cardiovascular Diseases – An Overview", First International Congress on Hygiene and Preventive Medicine, Belgrade, Serbia, 22-24 May 2013.

Brooker³⁷ considered how one might interpret such risks in the context of third party safety risk in the vicinity of airports. Aircraft crashes are rare, but their potential effects to people on the ground near airports cannot be ignored. Studies on the risks to these 'third parties' have led to changes in UK policies on development near to airports. The results have been an important issue in planning inquiries, most especially the Heathrow Terminal 5 Inquiry.

Though incredibly infrequent, where they do occur, crashes are now most likely to occur in areas that are close to airport runways, because take-off and landing generally produce the most risks, generally occurring because of operational factors rather than from problems with aircraft design or engine technology. The UK Government established a system of Public Safety Zones (PSZs) for the busiest airports more than 40 years ago. PSZs are areas of land at the ends of the runways: within them, development is restricted in order to minimise the number of people on the ground at risk of death or injury in the event of an aircraft crash. The Department for Transport subsequently adopted a policy to limit individual risk to 1 in 10⁻⁴ per year and restrict develop of new housing or sensitive developments to 1 in 10⁻⁵ individual risk.

Brooker concluded that on the basis of the evidence from Babisch, that at the highest noise levels, above 70 dBA L_{eq} , the aircraft-noise induced heart attack risk would exceed the 10⁻⁴ level. Although there are now very few individuals exposed to such high noise levels living around airports, the implication of the research is that noise induced health risk could be treated the same as third party safety risk. Questions remain over the validity of such research, especially the relatively large uncertainty and whether confounding factors have been fully accounted for.

In the Airports Commission final report, a review of the potential impact of property removal alongside land rezoning in order to mitigate the highest noise and potential health impacts on local residents would help to give certainty that the numbers of people affected by new noise will be minimised.

37 Brooker, P, "If High Aircraft Noise Exposure Increase Heart Attack Risk, What Do We Do About It?"; Acoustics Bulletin, pp31-35, 31 (6), 2006.

Barriers and other noise absorption mechanisms

Noise barriers are used very effectively to mitigate road and railway noise, however they are less effective at mitigating aircraft noise, with the exception of aircraft ground noise, e.g. that associated with taxiing and engine testing, due to the simple fact that once airborne, aircraft noise will propagate over the top of barriers. There are, however, circumstances where noise associated with the take-off or landing ground roll can and has been effectively mitigated.

Man-made earth bunds have been used as noise barriers, whilst also serving to reduce visual intrusion. More recently Schiphol airport has reduced start of take-off roll noise associated with its newest runway by surrounding it with undulating ground that disrupts the propagation of sound across the ground surface, reducing noise exposure levels.

It is recognised that the provision of physical barriers and/or bunds requires additional land take, adding to local pressures for development land. However, noting that barriers would often occupy land exposed to the highest noise levels that also may result in health risks, the CAA believes that barriers and/or bunds can play an effective role in contributing to mitigate aircraft noise in the immediate vicinity of an airport.

Airports, in particular when seeking to expand, should consider the potential to utilise noise absorption methods to limit the impact of aircraft ground noise – particularly to newly exposed populations.

Funding mitigation measures

At present, UK airports tend to spend less than their international counterparts per household impacted by noise. The following table indicates mitigation spending per passenger for the five largest airports in Europe.

Figure 8.1: Mitigation spending by major European airports³⁸

Airport	Period	Mitigation spending	Annual spend	2013 passenger numbers	Mitigation spending per passenger	Notes
London Heathrow	2007-2011	€37m	€7.7m	72.3m	€11	
Paris Charles de Gaulle	1995 - 2008	4,597 Residences insulated - €40m 55 public buildings - €9.55m 10,940 residences insulated - €97m 14 public buildings - €4.7m Total - €151.25m	€11.63m	62.3m	€0.19	
Frankfurt	2001 - ongoing	Private Residence Insulation Phase 1 - €55.8m Residence Insulation Phase 2 - €95.4m Compensation outdoor living areas - €51m Regional fund - €20m CASA buying programme - €100m Commercial Insulation commercial buildings - €7m Compensation outdoor areas - €2.5m buying programme - €21m Total - €352.7m	€29.39	58m	€0.51	Spending period assumed to 2013
Amsterdam Schiphol	1984 - 2005	Insulation: Phase 1: €127m Phase 2: €395.8m Phase 3: max. €99m buy up / demolition noise: €22.8m Total – €644.6m	€30.69m	52.6m	€0.58	
Madrid Barajas	2000 - 2013	€150m	€11.53	39.7m	€0.29	

38 Sources: CDG, AMS, MAD <http://www.boeing.com/boeing/commercial/noise/list.page>; Frankfurt and Heathrow from correspondence with the airport operators.



In the US noise compensation schemes appear to be much more generous than current UK schemes, both in terms of eligibility and the level of funding provided. US schemes are funded by charging a fee per ticket sold that is then distributed to mitigate the most significant noise issues. At Chicago O'Hare Airport over \$550m³⁹ has been invested in noise mitigation.

Increasing spending on mitigation to compete with international best practice would be expensive given the UK's population density, particularly at Heathrow where noise affects many more people than any other European airport. However, increasing spending significantly above today's levels would achieve greater equity between airports and communities, and the CAA believes that it is likely to be a pre-requisite for the significant expansion of any airport.

³⁹ From the O'Hare Noise Compatibility Commission <http://www.oharenoise.org/>

CHAPTER 7

Incentivising the aviation industry

So far we have focussed on manufacturers' ability to enhance noise performance and airlines and airports operational approaches to reduce noise and mitigate that which cannot be designed or operated out of the system. The next step is to consider how the aviation industry should most effectively be incentivised to go further than buying the quietest aircraft as they renew their fleets.

Sustainable aviation's noise roadmap

In the UK, Sustainable Aviation is the aviation industry group to develop a programme that ensures environmentally-friendly aviation. The group was formed in 2005, and brings together airlines, airports, manufacturers and air navigation service providers (ANSPs). As such, it offers the potential to provide a coordination role to drive industry improvements across the board on noise performance, and ensure that the right relationships are in place to move noise management strategies from proposals to reality.

In April 2013, Sustainable Aviation launched their noise road-map⁴⁰. This focussed on applying the ICAO Balanced Approach to the UK, and concluded that aircraft innovations and engine technology, operational advancements and better land-use planning offer the potential to reduce UK aviation noise output by 2050 compared to 2010, despite a forecast growth in flights. The road-map highlighted the potential for flight numbers across the UK to double without an increase in noise from today.

The road-map identifies demand increases and the potential for technological improvements and operational mitigations combining to allow flight numbers to increase, but does not focus on the requirement for additional runway capacity and the associated issues for local residents.

In presenting the case that flights can double without an increase in noise, there is a danger that the perception of complacency could lead to local communities around airports, who today feel significantly negatively

⁴⁰ The SA Noise Road-Map, A Blueprint for Managing Noise from Aviation Sources to 2050, April 2013, <http://www.sustainableaviation.co.uk/wp-content/uploads/SA-Noise-Roadmap-Publication-version1.pdf>

affected by aviation noise, feeling marginalised and continuing to oppose any expansion. In addition, as explored in previous chapters, although the 57dBA L_{eq} is the Government's accepted measure for significant aviation noise annoyance, many people challenge its relevance in reflecting their experience of noise, so simply aiming to maintain noise at today's levels within that contour may be unhelpful if it leads to increased noise as measured by other metrics.

With noise from Heathrow alone affecting significantly more people than any other airport in Europe, the CAA believes that the status quo is not acceptable, particularly if airport expansion is to occur. As such, the CAA believes that while Sustainable Aviation is an effective forum to coordinate efforts to manage and mitigate noise, industry's ambition must be to actively improve noise performance before, during and after expansion so as to ensure that in future, fewer people are significantly affected by aircraft noise than today.

The role of airports

Airports face a difficult balance in managing their noise impact. While they are clearly the focal point for local community annoyance, they do not have direct commercial relationships with the aircraft and engine manufacturers where the most significant improvements in noise performance occur, and as they do not operate flights themselves, they have limited ability to influence improvements in operational noise mitigation. However, in several areas, they do have powerful tools to influence other actors, particularly airlines, to improve their noise performance. These are explored below.

Landing charges

In October 2013, following a request made by the DfT in their Aviation Policy Framework, the CAA published a report on environmental incentivisation in landing charges⁴¹. Although airports do not have direct levers to influence manufacturers, by focussing their charging regimes to incentivise the best performers, they can exert indirect pressure via their airline customers, and further influence how airlines choose to manage and operate their fleets.

The report sets out a series of good practice principles for airports to use when setting landing charges to encourage quieter, and cleaner, flights:

41 CAP 1119: Environmental charging - Review of impact of noise and NOx landing charges, October 2013: <http://www.caa.co.uk/application.aspx?catid=33&pagetype=65&appid=11&mode=detail&id=5803>

1. Noise charging categories should be based on ICAO certification data, namely the margin to Chapter 3, to incentivise best-in-class technology use.
2. Noise charging categories should be of equal width, typically 5 EPNdB, or narrower, to ensure adequate differentiation of noise performance.
3. The noise charging categories used at a given airport should cover the full range of aircraft in operation at the airport. This range should be reviewed periodically and modified as appropriate.
4. Noise charges for operations occurring at night should be greater than those that occur during the day.
5. Where noise-related charge differentials occur depending on the time of day of an operation, the scheduled time of the operation should be used as opposed to the actual time. Penalties may be used to disincentivise operations scheduled to occur on the cusp of the night period that regularly fall into the night period.
6. There should be a clear distinction between noise-related landing charges and any non-noise-related charges, e.g. demand-related charges.
7. Charging schemes should ideally be harmonised across airports within the UK. Aircraft should be treated similarly from one airport to another, even if the charges at each airport are different.

Although some airports adopt some or all of these measures, unified adoption would increase their effectiveness and enhance national noise performance.

Facilitation

As the main interface between the many players who can have an impact on noise, airport operators have a unique ability to facilitate and coordinate noise management beyond incentivising airlines and others through their landing charges. They are also clearly beneficiaries of improving noise performance. Whether from simply satisfying local residents that they are doing their best to improve life for communities around the airport, or through unlocking the potential to expand, doing more to manage noise is in airports best interests.

Many of the operational improvement techniques set out in Chapter 5 require a significant amount of coordination and a concerted push to ensure buy-in from the relevant parties, be they airlines, ANSPs, regulators, or local and national government. Airports are not only well placed to lead this process, but as the organisation often most closely associated with noise nuisance, and with most to benefit from if community objections to growth are overcome, they should be at the heart of efforts to facilitate operational improvements.

If they don't already exist, airports should provide effective fora to coordinate and drive operational techniques to mitigate noise impacts.

Further incentivisation

Operational restrictions

As the ICAO Balanced Approach sets out, if enough is not done under the first three pillars, operational restrictions are a final necessity, and serve as a very blunt incentive for industry to do more where they have powers.

Given that aviation rarely has influence over land use and planning, this means its focus must be on operation and manufacture to limit operational restrictions.

In some areas, this is likely to remain challenging to reduce noise, for instance, the South East's dense population means night flights are likely to remain restricted for the foreseeable future at the major London airports.

Improving noise performance also reduces the risk of additional restrictions being imposed - for instance, at Frankfurt Airport, recent court decisions have seen night time operations stopped altogether.

Sharing the benefits of noise improvements

Enhanced performance does have the potential to unlock some restrictions, and the CAA believes that unless airlines come to the fore in improving operational mitigation techniques, and procuring and managing their fleets to minimise noise for the maximum number of people, the additional capacity they seek in the south east simply will not be built.

This ought to serve as a clear incentive for airlines and others to focus on improvement.

If this does not enhance performance sufficiently, policymakers should consider stronger measures to ensure sufficient focus on noise management for the benefit of local communities, aviation consumers and the wider economy.

Noise envelopes

One method to lock-in the concept of sharing the benefits of expansion as part of the planning process is to set a noise envelope when developing capacity.

As part of the Aviation Policy Framework, the Department for Transport requested the CAA produce further guidance on the use and types of noise envelopes which may be used in the context of any proposals for new airport capacity and the work of the Airports Commission. In December 2013, the CAA published CAP 1129 to inform the definition of a noise envelope concept which can be applied to airports looking to increase their capacity⁴².

Noise envelopes are a concept utilised by policy-makers and airport officials to allow for capacity expansion within a noise-sustainable environment, by limiting growth at an airport to within set parameters based on noise metrics.

They allow local communities a degree of certainty that a noise threshold will not be exceeded while allowing movements to increase in a sustainable fashion. Envelopes can also be used proactively to manage capacity in a way that limits noise for the benefit of communities; increases in capacity improve consumer choice and value; and builds greater resilience into the airport system to protect consumers from delay.

In addition to potential benefits in delivering additional capacity, noise envelopes also incentivise airlines to utilise their quietest aircraft on routes that are covered, support the development of quieter aircraft as they renew fleets, and operate their aircraft as noise efficiently as possible.

42 CAP 119 Noise Envelopes, December 2013: <https://www.caa.co.uk/docs/33/CAP%201129%20Noise%20Envelopes.pdf>

Types of envelope

There are three broad approaches to creating noise envelopes:

- Limiting aircraft movements by:
 - using a cap (as seen at Heathrow currently);
 - introducing a quota with aircraft types assigned a 'noise factor' according to their performance (as seen with the current Night Noise Regime); or
 - setting passenger number limits.
- Restricting noise exposure by using contours to define operational restrictions; and,
- Setting noise level caps by for example setting caps based on acceptable levels of noise as measured by noise monitors.

The CAA believes that a noise envelope underpinned by law could be designed as an effective tool to afford communities confidence that airport expansion can be managed sustainably.



The imposition of a noise envelope for any new runway capacity developed in the south east, which would contain a series of trigger points to allow new capacity to be utilised only when noise limitations are met, could have benefit for noise management and community trust. Imposition of such an envelope would be a decision for the Airports Commission and Government. The final design of such an envelope could be agreed by the Airport Community Engagement Forum.

We advise that in developing it, these principals should be followed:

- stakeholders at the chosen site must input to and agree the envelope's criteria, limits and means of implementation and enforcement in the context of wider expansion plans and incentives for communities.
- the benefits of future technological improvements must be shared fairly between the airport and its operators, and local communities.
- the life-span of the envelope must be agreed, and its parameters set to maintain appropriate sharing of the benefits over its intended life-span.
- Government should implement legislation to secure the envelope's status in law, ideally alongside the National Policy Statement on aviation. This legislation could also cover resilience-related capacity considerations to avoid over-scheduling to the detriment of consumers even if noise limits are not breached.
- If such an envelope is proposed, in setting out their National Policy Statement, government should apply the CAA's suggested principals to setting the noise envelope.
- Planning authorities considering additional capacity elsewhere should consider the utility of introducing a noise envelope to manage community noise impacts, and apply the principles if they choose to impose one.

Noise tax

Under the Chicago Convention, aviation fuel and other related goods are exempt from taxation. In the UK, aviation is taxed on a per-ticket basis under the Air Passenger Duty regime, with rates depending on class of travel and distance of flight. Other countries adopt similar measures, with some also imposing local or national noise taxes.

If other measures do not go far enough to engage the aviation industry in the effort manage to noise, policy makers could consider a further

incentive applied with the introduction of a noise tax⁴³. Similar to landing charges, this measure could be used to incentivise airlines to procure the quietest aircraft possible and use them at airports where the benefits would be realised to the most people⁴⁴. This type of trading off is only possible with a nationally imposed scheme, as individual privately owned airports do not have the same levers (or incentives) as the state here.

At present, taxes and charges levied on UK airlines and passengers are relatively high compared to international competition⁴⁵. APD receipts for an average flight to the United States carrying 275 people are estimated at around £15,000 (depending on seat occupancy and cabin class split), with averaged profit for such a route estimated at around £4,000 on estimated revenue of around £80,000⁴⁶. This shows that a per passenger noise tax would not have to be high to have a significant impact on route profitability and potentially viability. Such measures should therefore represent a last resort and if introduced would need careful consideration to design them in such a way as to be impactful but not excessively detrimental to passengers and airlines.

If introduced, one option would be to hypothecate receipts from a noise tax to fund the types of scheme that benefit local communities explored in Chapter 8, for instance sustainable transport schemes, community centres, sports and recreation facilities and small business development funding, therefore directly benefitting those with the most to lose from airport expansion.

Such a tax would also reflect the environmental disbenefit of flying in ticket prices in a clearer way than current landing charges do, internalising noise impact for passengers more directly.

43 Pearce & Pearce's *Setting Environmental Taxes for Aircraft*, 2000, suggested a metric to assess noise externality and thus apply a noise tax at Heathrow. For instance, they proposed a disbenefit amounting to £34 per 737-400 arrival at Heathrow. Available here: http://www.cserge.ac.uk/sites/default/files/gec_2000_26.pdf

44 For instance, if faced with choosing between operating an Boeing 787 on a route with approaches over densely populated areas or one in a rural area, taxes can be designed to encourage airlines to choose to use the quieter aircraft where it will benefit more people, in a way that an individual airport's landing charges cannot.

45 Air travel taxes as a proportion of total revenue represents around 11 % for easyJet and 8% for British Airways, as opposed to around 5.5% for German Wings and around 1.5% for the Lufthansa group. See the economic impact of Air Passenger Duty, A study by PwC: <http://corporate.easyjet.com/~media/Files/E/Easyjet-Plc-V2/pdf/content/APD-study-full.pdf> for more.

46 Estimates worked up on the basis of publically available data from the CAA's website, based on 2011/12 financial information submitted by British Airways.

France introduced such a noise tax, the Tax on Air Transport Noise Pollution (TNSA) in 2003, with the tax coming into effect in 2005⁴⁷. The tax affects all aerodromes with over 20,000 large aircraft movements annually. In 2010 it raised just over €58m⁴⁸. The tax is set at a level varying depending on the size of population affected by the aerodrome and depending on aircraft takeoff weight, noise rating and time of day⁴⁹. Affected aerodromes collect the tax on the state's behalf, charging airlines as an element of their landing charges. Receipts from the tax are ring-fenced to fund neighbourhood improvements in the vicinity of the airport, and fund noise mitigation works (ring-fencing improvement funding is explored further in Chapter 7).

Government should consider the potential for a future noise tax to incentivise airlines to procure and operate fleets in the most noise efficient fashion possible, if other methods are not successful, and to internalise noise impacts in consumer decision making.

Were it to be considered, the design of such a tax should, as the French one does, reflect the individual circumstances of different airports and their varying noise impacts - ensuring that impacts are proportionate and based on a clear cost/benefit analysis. If introduced, the CAA believes that it would more equitable for revenues to benefit local communities, either directly via funding insulation measures or indirectly through supporting schemes which benefit the entire local area.

47 More information from the French Ministry of the Environment and Sustainable Development in English can be found here: https://www.formulaires.modernisation.gouv.fr/gf/getNotice.do?cerfaNotice=51058%2307&cerfaFormulaire=12503*07

48 See table on page 49 here: <http://www.acnusa.fr/projets/acnusa/srcs/www/userfiles/webeditor/file/3%20pages%2038-55.pdf>

49 The formula to calculate the tax is: TAX DUE = decimal logarithm (log) of the aircraft's Maximum Takeoff Weight x modulation coefficient x aerodrome rate. For example, for a day time departure of a Boeing 747-400 leaving Paris Charles De Gaulle, with a Maximum Certificated Take-off Weight of 396,893kg. $\text{Log}(397) = 2.60$. The 747-400 is in acoustic class 5a, so a daytime (6am-6pm) operation has a Coefficient de Modulation (CM) of 1. And the tax rate is €22. So the total tax due is $2.60 \times 1 \times 22 = €57$.

CHAPTER 8

Engaging the community

The previous chapters have explored the various measures available to the aviation industry and policy-makers to minimise noise at source, reduce noise operationally, and mitigate the impact of noise on the ground, as well as the tools available to incentivise industry to adopt the approaches.

Noise performance over the past half century, and community perception of the noise annoyance indicates though that even with these measures, there is likely to remain a vocal minority of residents opposed to airport operation, let alone expansion.

While undoubtedly local communities see some benefits from nearby airports, and some may feel these outweigh the negatives, some local people feel the disbenefits of noise outweigh the positives. Experience at airports overseas (explored more fully in the following chapter) indicates that more can be done to share the benefits of aviation between consumers, the industry and most importantly the communities that suffer detriment caused by aviation and its passengers.

Trust

A significant problem with attempts to engage local communities in discussion around airport expansion is a lack of trust between parties. A particular problem within the densely populated south east is communities' sense that airports, airlines and government are focussed solely on expanding capacity with little consideration of the detriment to the people who live nearby. In public debate, community leaders also often highlight past promises that have been breached when considering commitments to future limits on airport expansion - for instance highlighting a statement that were Heathrow to be given permission to develop a new fifth terminal, there would be no need for additional runway capacity.

A large part of the trust issue can be understood in the context of the sense from some members of the local community close to airports which have or sought to expand previously (for instance Heathrow and Stansted) having the sense that the local population's voice has not been heard during the decision making process. A further issue could be a sense that local people have little say in how airports are operated - and if new capacity comes in to use they will be unable to influence how it is utilised.

These issues were also faced by European airports (particularly Amsterdam Schiphol and Frankfurt) as they sought expansion - and learnings drawn from their experiences influence our recommendations in this chapter. These experiences are expanded in more detail in chapter 9.

Information publication

In December 2012, the CAA was given a duty to publish or arrange for the publication of environmental information on the effects of aviation on the environment. Following a full public consultation which concluded in Jan 2014 with the publication of a policy statement and our proposed next steps, the CAA is using these new duties in three complementary ways:

- Consolidating existing aircraft noise information hosted on the CAA's website and identify and fill any gaps in information as necessary. One such example was explaining the CAA's role in producing and providing information about aircraft noise. This has been completed and can now be viewed at www.caa.co.uk/noise. Longer term this information will be form part of the new Aviation Environment Information Portal that we are developing to provide a 'one stop shop' for people seeking information on aviation's impact on the environment. This portal is currently under development and will be available at the end of 2014.
- Publishing best-practice guidance for industry on communicating noise information and impacts for local communities and other stakeholders, which Consultative Committees and other groups can use to better understand the impact of aviation noise and to hold airports to account. Our consultation provided anecdotal evidence that there was some very good examples of better noise communication; and we will publish this guidance which will be developed in partnership with a range of stakeholders. This guidance will begin to be available from September 2014.
- Examining the use and utility of post-code mapping tools and deciding whether there would be benefit in the CAA developing a national airport noise post-code mapping tool in order to help people understand the impact of noise on their area. We are conscious that several airports are currently in the process of developing such tools and do not want to duplicate so we will be looking at the feasibility of this before proceeding further. We will publish our findings in the spring of 2015.

The consultation responses were very clear that the CAA could add value by making better use of the large amount of noise information that currently exists in terms of accessibility and making it easier for the lay person to understand. As we develop our aviation environment information portal further we will monitor on an ongoing basis if there are information gaps and therefore need to formally use our duties. We are committed to delivering our information duties using better regulation principles as outlined in our Statement of Policy.

Airport community engagement forum

Given the importance of effectively engaging local communities in capacity expansion, and ensuring that local people have a say in key decisions around how capacity is utilised, and how they are compensated to reflect the disbenefits of living close to the new runway, there is a potentially vital role for a forum devoted specifically to helping to secure community buy-in at the final site for proposed expansion chosen by the Airports Commission. In considering this role, the CAA's thinking has been influenced by the experiences of both Schiphol and Frankfurt in their recent expansions and the community fora they created.

An Airport Community Engagement Forum charged with ensuring clear, effective links and dialogue between local communities, the aviation industry, policy-makers and planners would help to facilitate community engagement and could help to ensure the Airports Commission's recommendations are delivered.

For such a Forum to be effective, it must have respected, independent and objective governance to give weight to its recommendations around noise management strategies, community engagement and compensation measures. The Forum's core aim would be focussing on how new capacity is developed and utilised, rather than whether such capacity should be created – a decision which is for the Airports Commission and Government.

It is vital that this forum has the trust of all stakeholders, has real oversight powers and is an authoritative voice for it to achieve its aim of securing community trust in the process of expanding capacity.

Incentives

Airports currently tend to fund some or all of the noise insulation and mitigation technology for households within certain areas. For instance, at Heathrow, around 40,000 homes affected by night noise are eligible for half funding of replacement bedroom windows, or free secondary glazing for bedroom windows, and free loft insulation. These schemes are explored in more detail in Chapter 6. Moving beyond payments to individual households that are directly related to reducing noise impact, there are a series of measures potentially open to airports and government to adopt to help communities benefit from airport expansion rather than solely suffering from detrimental impacts.

Financial benefits

The industry itself, its shareholders, the business community, leisure travellers, the government and the UK economy all benefit from the aviation industry. At present, the local communities who are impacted by aviation noise and emissions are the significant losers, albeit that they may also gain a share of the benefits. This is both inequitable and a limit to the industry expanding, to the benefit of the other groups mentioned. As such, the CAA believes that industry and government must do more to ensure that local communities benefit from expanding aviation capacity if it is to be successfully delivered. There are several possible models for this approach to follow, which are explored below.

Financial incentives for local communities could be an important part of compensating people for the negative impacts of aviation. The Airports Commission may propose such incentives in their final report – these are likely to be most impactful if local communities have a say in their design and if they are underwritten by law to ensure that residents can rely on them.

The government's Community Energy Strategy⁵⁰, published in January 2014, explores options within the energy sector to share the benefits of new energy schemes more effectively with the communities they impact, either through payments or sharing new energy capacity more directly, highlighting similar pressures and considerations in other sectors. The Strategy envisions that "by 2015 it should be the norm for communities to be offered the opportunity of some level of ownership (of new onshore renewables development) by commercial developers."⁵¹

Landing charges

Airports typically levy landing charges on airlines based on a variety of factors (including for instance numbers of passengers carried, take-off and landing weight, and noise rating). Alongside charges for things like pier service and parking, and commercial revenues from parking and retail, these charges form a significant proportion of their overall revenue.

Developing new capacity is likely to lead to significantly increased landing charges to fund the construction, and be followed by significantly increased passenger numbers, increasing airport revenues (and in likelihood their tax bill). A proportion of this additional revenue could be hypothecated to fund projects that benefit the communities affected by the negative impacts of the new capacity, this could include funding:

- Sustainable transport schemes (which would have the additional benefit of improving local air quality which is also damaged by capacity expansion)
- Community centres
- Sports and recreation facilities
- Small business development funding
- Noise related landing charges are explored in Chapter 7 as a potential method to better incentives airlines to take up operational noise mitigation strategies. Direct hypothecation of the noise element of landing charges would provide clear notice of airports' commitment to their communities.

50 Community Energy Strategy Full Report, January 2014:
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/275163/20140126Community_Energy_Strategy.pdf

51 *ibid* p8.

- Scheme proposers should consider the potential to do more to engage communities by spending more than they presently do on community engagement opportunities.
- In reaching its final recommendation, the Airports Commission could consider the potential for hypothecating an element of the airport landing charges and slot fines to benefit local communities, either directly via payments or indirectly through local schemes. This could include considering the potential to enhance deliverability of the proposed project, weighed off against the impact on its financeability.

Co-operative ownership / share distribution

A more radical mechanism to redistribute the benefits of additional airport capacity would be to develop a model that allows for a direct or indirect share of ownership for local people. As well as allowing residents to benefit from the airport's profits, this model could also have the advantage of allowing locals to feel more involved in the operation of the airport, and could engender a more direct sense of mutual benefit around additional noise.

As mentioned above, this approach is expected to become the norm in the renewable energy sector, where communities are expected to be offered shared ownership of new developments in the coming years. Government is facilitating this approach by publishing guidance to help communities negotiate benefit packages, creating a new unit to work with local communities, and even providing funding to help develop community energy groups.

However, approaches such as this could potentially have a significant impact on the airport operator's ability to fund development and the potential investment environment for added capacity.

Although they are radical and likely to be challenging to implement, scheme proposers could consider the potential for utilising a novel ownership structure to better engage communities with airport success.

Fines

At present, airlines which breach either slot rules or noise rules are subject to fines. Breaching slot rules can include operating outside of an airport's opening hours, so increasing noise for local communities, but for a fine to be levied the breach must be repeated and intentional. In the UK, the slot coordination company ACL is charged with overseeing slots and levying fines. In the first place, revenues from fines are used to cover

its costs, with any excess accruing to the exchequer. For noise-related fines levied by airports, revenue accrues to the airport concerned, where it is used to fund local community benefits. For noise-related landing charges, the revenue usually accrues to the airport, where it can be used to reduce other fees.

Generally, because of good compliance with noise restrictions and slot coordination rules, revenue from such sources is reasonably low. If schemes were tightened to incentivise even better performance, or to better balance community disbenefits from expansion, if all revenue directly benefited local people, either through funding community schemes or by direct payments to those most affected, it would help to internalise noise externalities.

Tax breaks

Aviation is not the sole benefactor of the success of the industry, through corporation tax and Air Passenger Duty, the exchequer also gains significantly from increased passenger numbers, and as the debate around increasing capacity has highlighted, the wider economy would also benefit. An extra million mid-haul flights a year would see the exchequer benefit considerably⁵². As such, another model to consider is to fund tax breaks for local people and businesses through either a new hypothecated levy on additional flights; through hypothecating additional revenue from new flights; or from general taxation of aviation.

A noise tax such as that explored in Chapter 7 could also be hypothecated to fund tax breaks for locals, as opposed to benefitting taxpayers more generally, or could fund the types of project that benefit communities as a whole.

Government and local authorities should consider the potential for tax breaks for local people and businesses to help to compensate local communities.

⁵² Air Passenger Duty receipts for the 2011/12 financial year were £2.8bn. A new runway constructed at Gatwick could serve up to 34m additional passengers; at Heathrow a new north-west runway could serve an additional 40m passengers, increases of 15% and 18% respectively from the 221m in 2012, implying increased APD receipts of up to £500m.

CHAPTER 9

The international picture

While the UK's recent experience of runway development and capacity expansion is limited, particularly in the South East, Europe and further afield have seen significantly developed runway capacity over the past two decades. Europe's five largest airports alone have seen four runways opened since the beginning of the century, and examination of the methods they have taken to mitigate noise and engage their local populations is helpful in providing best practice for adoption by the Airports Commission and policy-makers in the UK.

Frankfurt Airport

In the mid-1990s, initial proposals to expand Frankfurt Airport from its 1980s configuration of three 4,000 metre runways (all slightly longer than Heathrow's runways) were mooted. Examination of the process the airport and government went through in developing the eventual 2,800 metre fourth runway is helpful both for positive approaches and lessons round contentious areas.

Runway development process

The process for expanding Frankfurt from three to four runways was strongly coloured by the experience of building the third runway, which took from 1973 to 1984. Protests surrounding the project extended through the period, and continued when the runway was in operation. The protests were both amongst the most serious environmental activism seen in Europe, witnessing the deaths of two policemen during one incident, and formed the core of many future anti-expansion arguments. The protests have been described as being close to a 'civil war' by those close to the debates around German airport expansion.

The eventually created third runway is not entirely independent of the original two, is limited to use only for departures, and as such cannot be used to full capacity. In the mid-nineties, plans began to be made about how to manage the process for creating a new fourth runway, learning the lessons from the third runway. Planning formally began in 1997, and a twin-track approach was pioneered from the very beginning. Alongside the formal process for approving any large infrastructure, with

masterplans, government approval, planning processes, and permission from regulators, a twin process of mediation began that engaged elected representatives of the most impacted local communities in the process. This mediation focussed on engaging local government and mayors, as opposed to citizens groups, NGOs or protest organisations, with the rationale that as elected representatives, they were the best proxy for the feelings of the entire community. The mediation process resulted in the creation in 2000 of the Regional Dialogue Forum to facilitate community engagement during the expansion process. The Forum existed until 2008.

This dialogue began with a unified response from all communities that they would oppose any expansion, no matter where. However, over time, the mediation process and the measures proposed by Frankfurt to reduce noise for all affected by the airport persuaded the local governments that the benefits were strong enough for them to allow capacity to be developed with strict limits on its use.

Participants in the mediation process and the subsequently created local community engagement forum emphasise a series of key factors which created effective dialogue between all stakeholders:

- Parity of information between all participants is vital so communities can engage the airport and its users on a level playing field
- The process cannot be tainted by party politics - this helps both with trust and continuity
- Developing individual relationships, if necessary one at a time, is more important to developing trust than institutional arrangements
- There must be clear, fair and transparent sharing of benefits if expansion is to work
- The entire process requires sustained pressure on industry from government (at all levels) and regulators.

Noise abatement measures

From a shortlist of three options, the final location put forward by Fraport in 2001 was to the airport's north-west to minimise overflight of densely populated communities. The design was for a shorter runway than the existing three, which would be used solely for arrivals (in contrast with the third runway's use solely for departures).

It was also agreed that the largest, noisiest aircraft types would not be allowed to use the new runway (Boeing 747s, MD11s and Airbus A380s are all banned) and that reverse thrust would only be utilised on landing for safety reasons. In addition, tighter night noise limits were put in place for the entire airport - these were subsequently further tightened in 2011 (see below).

Forum Flughafen Und Region

In 2006, the government of the Hesse region created the Forum Flughafen Und Region (FFR) as an ongoing forum for dialogue between the community, the regional government and the aviation industry (replacing the Regional Dialogue Forum). Its main task is to provide neutral information to stakeholders, including online noise monitoring information on routes flown, heights and noise generated, and forecast information on runway operating direction. It provides further objective information on issues at the airport and development, and undertakes noise research.

In addition, the FFR includes an Expert Committee on Active Noise Abatement, which studies measures for active aviation noise abatement, before offering advice on potential measures. This is operated alongside existing legally prescribed procedures set out by approval authorities, flight safety bodies and the flight noise committee.

Night flights

During the initial fourth runway development process, proposals to stop night flights at the airport between 2300 and 0500 were mooted, but eventually overruled by the regional government. However, in 2011, following a judicial challenge brought by local community groups, a ban on all night time operations at the airport was introduced by the regional courts, later upheld by the national court. The ruling was welcomed by Frankfurt's mayor and the German Environment Agency. At present, there are no night flights at Frankfurt Airport between 2300 and 0500.

The change of policy during operation could cause financial and operational issues, and it seems ideal to agree eventual mitigations prior to proceeding with construction to ensure the business and economic case for expansion are clear in light of them.

Ongoing protest

The measures to engage the local community more effectively, be more transparent and do more to mitigate noise did not assuage all anti-airport and anti-expansion sentiment around the airport. Two and a half years after the fourth runway began operations, each Monday evening at 1800, significant numbers of protestors demonstrate against the new runway within Terminal 1. These protests are not led by the local government bodies represented within the FFR but by citizen action groups.

Amsterdam Airport Schiphol

Amsterdam Airport Schiphol is Europe's largest airport in terms of runways (with six) and is arguably the continent's oldest hub, beginning operations in 1916. With a high population density and a long history of international aviation, the Netherlands' situation and challenges are very similar to those faced by the south-east of England.

Runway location

Schiphol's sixth and longest runway was opened in 2003, and is located at a distance from the single terminal across two A roads, in order to reduce noise for communities living close to the airport. This means that aircraft using the runway face taxi-times of up to 15 minutes to travel from the runway to terminal, but does allow both landings and departures to avoid major population centres.

Alders Tafel

Following the beginning of operations from Schiphol's newest runway in 2003, the Alders Tafel was created in 2006 to advise the Dutch government about the development of Schiphol Airport and its surroundings, as well as Eindhoven and Lelystad airports, until 2020. A former environment minister, Hans Alders, chairs the forum. The forum's recommendations are reached following consensus from participants at the table. Since its inception, the forum has proposed:

- Selective growth of Schiphol Airport (achieved via movement limits)
- Noise abatement measures including new flight paths
- Operating restrictions and fees
- Suggested quality of living environment measures
- Development (and subsequent revision) of a new noise management system
- Overseeing a noise insulation criteria and programme
- As well as offering recommendations to government, the forum also engages with local communities to ensure they are informed about the airport's development, and provides noise abatement, and other, information to local communities.
- Some of the concepts adopted by the forum are similar to the idea of a noise envelope. This will be formalised beyond 2020 with further growth only allowed providing noise constraints are not exceeded. As such, growth can only be enabled by reducing noise, and even in this case, the benefits must be shared between the community and the airport.

CHAPTER 10

Recommendations

The CAA is clear that the aviation industry, the regulator, and policy-makers must work in a unified fashion to tackle aircraft noise impact – this is not only an obligation owed to the communities who experience many of the downsides of aviation, but as we face increasing capacity squeezes, it is likely to be a pre-requisite to see new infrastructure constructed.

It is widely accepted that there is no single solution to aviation noise and instead it must be managed and actively reduced through a series of complementary measures, all of which should be encouraged through a unified set of policies to ensure industry have the right incentives to act.

Even if this approach is successful in reducing aviation noise to a significantly lower level than that which communities experience today, pressures imposed by demand growth mean that it is vital to do more to engage those local people who feel that expansion is a zero-sum game where they are the sole losers and the aviation industry, travelling public, government and wider economy all gain at their expense.

For aviation, facing this challenge means accepting that greater ambition is necessary to achieve step changes in performance; for policy-makers, that means facilitating better performance through incentives and policy levers to aid industry in reducing noise.

Given their inherently close relationship with local communities, often facilitated through existing Consultative Committee structures, airports are best placed to take a lead in coordinating industry action, and in assessing which measures best fit their individual circumstances.

In relation to the Airports Commission process, the final location chosen for a new runway will affect which measures are most appropriate to adopt. As much as possible, this consideration should be done in consultation with the communities who are affected, rather than being decided by aviation in isolation.

The Government's policy position on aviation noise is to limit and, where possible, reduce the number of people in the UK significantly affected by noise – in the context of the debate around aviation capacity, we believe that if industry is to be able to expand in the south east, it must go further. A successful noise strategy would not only focus on

actively reducing the numbers of people affected by noise, but would also seek to compensate those who are still affected in full reflection of the disturbance they suffer, and would engage all of those affected by noise in the process of managing operations, designing mitigations and proposing compensation schemes.

The proposals set out in this document are summarised below.

Manufacture

The most significant potential noise reduction benefits in terms of reducing noise can be produced through enhancement in airframe and engine manufacture. It is through creating quieter aircraft that the significant benefits in noise reduction have been driven since the 1950s.

Airlines

The CAA urges airlines to continue to focus on improving noise performance when they purchase new aircraft. Measures to incentivise airlines to prioritise noise performance over and above other priorities are explored in the incentivisation section below. This is important as with the recent introductions of two new aircraft types with significant noise benefits over their predecessors, operators now have more options when considering new type purchases.

Policymakers

Policymakers should be aware of potential noise and carbon trade offs when considering incentives around sustainability and ensure that perverse incentives are not introduced which lead to increasing noise impacting local residents.

Manufacturers

Aircraft manufacturers face a series of pressures when they come to consider new product innovations including cost, configurability, efficiency, emissions, comfort, and noise performance. While many of these elements have an impact on aviation's externalities, improving noise performance uniquely improves life for people who may see little or no benefits from aviation. We would strongly encourage manufacturers to continue to work to drive noise improvements, working collaboratively, and ensuring that trade-offs with other elements do not mean increasing noise.

Operate

Continuous Descent Operations (CDO)

We recommend airports consider the potential for such league tables to add value in their efforts to reduce noise, and consider other measures to ensure airlines adopt CDOs.

Low power low drag

Airports should consider measures to incentivise airlines to deploy landing gear at the appropriate point to balance operational and safety requirements and noise reduction.

Reduced landing flap

Although a number of operators already use utilise the reduced landing flap technique, such a measure could be adopted relatively quickly by others to enhance noise benefits. Airports should work with their operators to enhance adoption of reduced landing flap.

Displaced landing thresholds

We will work with industry to gain a better understanding on the issues associated with displaced landing thresholds and will engage with industry, government and the Airports Commission to move forward operational assessment of the potential benefits.

Slightly steeper approaches

The aviation industry should consider the potential for slightly steeper approaches to impact on existing practices such as low-power/low-drag and reduced landing flap techniques as part of consideration of adopting this procedure where appropriate to mitigate noise.

Two-segment Approaches

We will work with industry to explore the potential for two-segment approaches, and request that the broader aviation industry actively engage with the work we have initiated with British Airways, and consider the potential for this concept to significantly reduce approach noise.

Optimised lateral path

The CAA will continue to engage with industry through the Airspace Change Process and the Future Airspace Strategy programme to identify opportunities for optimised lateral paths to deliver noise benefits.

Mitigate

Insulation funding

Airports should assess their insulation schemes within the context of their individual circumstances, but when insulation funding is offered, it is most effective where funding is available in full for those most seriously impacted by noise. It is also sensible to allow eligible households to source their own supplier, allowing market forces to drive down overall costs. Where part funding is available, the proportion funded by the airport should depend on the level of noise impact – with more funding offered to those who experience greatest noise.

Property removal

In the Airports Commission final report, a review of the potential impact of property removal alongside land rezoning in order to mitigate the highest noise and potential health impacts on local residents would help to give certainty that the numbers of people affected by new noise will be minimised.

Barriers and other noise absorption mechanisms

Airports, in particular when seeking to expand, should consider the potential to utilise noise absorption methods to limit the impact of aircraft ground noise – particularly to newly exposed populations.

Expenditure

Increasing spending on mitigation to compete with international best practice would be expensive given the UK's population density, particularly at Heathrow where noise affects many more people than any other European airport. However, increasing spending significantly above today's levels would achieve greater equity between airports and communities, and the CAA believes that it is likely to be a pre-requisite for the significant expansion of any airport.

Industry incentivisation

When considering both manufacturing and operational improvements, policy makers and regulators often do not have direct powers to affect changes to improve noise performance. As such, consideration of a range of incentives to ensure the aviation industry fully reflects the environmental externality caused by noise in its decision-making is vital.

Landing charges

Airports which have not already done so should adopt the CAA's good practice principles for landing charges to encourage quieter operations set out in the Environmental Charges publication.

Facilitation

Where they don't already exist, airports should provide effective fora to coordinate and drive operational techniques to mitigate noise impacts.

Noise envelopes

The imposition a noise envelope for any new runway capacity developed in the south east, which would contain a series of trigger points to allow new capacity to be utilised only when noise limitations are met, could have benefit for noise management and community trust. Imposition of such an envelope would be a decision for the Airports Commission and Government. The final design of such an envelope could be agreed by the Airport Community Engagement Forum.

If such an envelope is proposed, in setting out their National Policy Statement, government should apply the CAA's suggested principals to setting the noise envelope. Planning authorities considering additional capacity elsewhere should consider the utility of introducing a noise envelope to manage community noise impacts, and apply the principles if they choose to impose one.

Noise tax

Government should consider the potential for a future noise tax to incentivise airlines to procure and operate fleets in the most noise efficient fashion possible, if other methods are not successful, and to internalise noise impacts in consumer decision making.

Were it to be considered, the design of such a tax should, as the French one does, reflect the individual circumstances of different airports and

their varying noise impacts - ensuring that impacts are proportionate and based on a clear cost/benefit analysis. If introduced, the CAA believes that it would more equitable for revenues to benefit local communities, either directly via funding insulation measures or indirectly through supporting schemes which benefit the entire local area.



Engaging communities

Even taking all the measures set out above, aviation noise will not be reduced to a level which annoys nobody in the foreseeable future, particularly if capacity expansion aims to meet demand growth. As such, alongside the proposals to minimise noise, more must be done to ensure communities are engaged with the aviation industry.

Information publication

The CAA will continue to develop proposals to make aviation's noise impact more easily understood to the public.

Airport Community Engagement Forum

An Airport Community Engagement Forum charged with ensuring clear, effective links and dialogue between local communities, the aviation industry, policy-makers and planners would help to facilitate community engagement and could help to ensure the Airports Commission's recommendations are delivered. For such a Forum to be effective, it must have respected, independent and objective governance to give weight to its recommendations around noise management strategies, community engagement and compensation measures. The Forum's core aim would be focussing on how new capacity is developed and utilised, rather than whether such capacity should be created – a decision which is for the Airports Commission and Government.

Financial incentives

Financial incentives for local communities could be an important part of compensating people for the negative impacts of aviation. The Airports Commission may propose such incentives in their final report – these are likely to be most impactful if local communities have a say in their design and if they are underwritten by law to ensure that residents can rely on them.

Landing charges and fines

Scheme proposers should consider the potential to do more to engage communities by spending more than they presently do on community engagement opportunities.

In reaching its final recommendation, the Airports Commission could consider the potential for hypothecating an element of the airport landing charges and slot fines to benefit local communities, either directly via payments or indirectly through local schemes. This could include considering the potential to enhance deliverability of the proposed project, weighed off against the impact on its financeability.

Ownership options

Although they are radical and likely to be challenging to implement, scheme proposers could consider the potential for utilising a novel ownership structure to better engage communities with airport success.

Tax breaks

Government and local authorities should consider the potential for tax breaks for local people and businesses to help to compensate local communities.

