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Research into the Improvement of the Management of Helicopter Noise

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University of Salford
A Greater Manchester University

Research into the Improvement of the Management of Helicopter Noise (NANR235)



Performed on
behalf of Defra

QinetiQ

Executive Summary

Introduction

This report describes research undertaken to investigate the improvement of the management of helicopter noise in the UK. This work was carried out on behalf of the Department for Environment, Food and Rural Affairs (Defra) by the University of Salford and QinetiQ (Farnborough) Ltd. The aims of this study were to determine the issues and the extent of the reported problem of noise from helicopter operations in the UK, and to develop practical guidance on the management of helicopter noise, including improvements in the handling of complaints.

Methodology

The methodology used to achieve these aims included a worldwide literature search, a survey of stakeholders, and a One-day Meeting carried out under the auspices of the Institute of Acoustics.

Conclusions

Nature and extent of the concern about helicopters noise in the UK

- 1) Problems due to helicopter noise are centred on helicopter infrastructure such as holding areas, heliports and aerodromes. However, unlike fixed-wing aircraft noise, helicopter noise is often not directly attributable to a specific heliport or airfield.
- 2) Compared with fixed-wing aircraft, the ratio of movements to the number of complaints received is generally small for most helicopter operations.
- 3) The consensus among stakeholders is that there is increasing opposition to the development of heliports on the grounds of noise disturbance.
- 4) There is no comprehensive database of helicopter movements in the UK. Consequently, it is impossible to determine the extent to which noise nuisance is a growing concern.
- 5) Precise determination of the scale of public concern about helicopter noise would require a careful social study.

Procedures in place for handling helicopter noise complaints

- 1) The CAA acts as a focal point for receiving and responding to aircraft-related environmental complaints from the public¹. The CAA encourages noise complaints to be made directly to the airport operator.
- 2) Complaints regarding military flights should be addressed to the base's community liaison officer.

- 3) Problems related to noise generated on the ground at aerodromes should be referred to the Local Authority.
- 4) Consultative committees to enable dialogue between residents, councils and heliport operators have been shown to improve understanding and acceptance by the public.
- 5) The failure to act on complaints is one of the largest causes of dissatisfaction and resentment amongst the public.

Rules and regulations governing helicopter operations

- 1) BHAB codes of practice aim to persuade helicopter pilots and operators to take more notice of environmental noise issues.
- 2) Helicopter noise certification does not address community annoyance caused by helicopter noise. A gradual reduction in the certification levels will not address public acceptability.
- 3) In England, the current land use planning guidance (PPG24) states that noisy and noise sensitive land uses should be kept apart. PPG24 provides advice to assist with the consideration of new residential development near existing sources of aircraft noise, but the guidance states that it should be used with caution where there is existing helicopter noise. PPG24 contains limited planning guidance on the noise impact of new heliports.

Dose response relationships

- 1) Helicopters can be up to 15dB more annoying than fixed-winged aircraft. However, helicopter noise levels alone do not account for annoyance trends in communities.
- 2) There is no single satisfactory noise index for the measurement or prediction of the impact of noise on the community.
- 3) Noise maps displaying Lden are not suitable to be used for the prediction of subjective response of communities to helicopter noise.

Opportunities for improvements

- 1) The UK has world-leading expertise in the sound insulation of residences from helicopter noise. This expertise could be exploited by designers and planners with regard to future building developments in the vicinity of helicopter operations.

- 2) The UK has world-class expertise regarding community response to soundscapes. This expertise could be exploited in future research, and to improve dose-response relationships for helicopter noise.
- 3) The UK has world-class expertise in helicopter noise propagation prediction and in the measurement of source noise from helicopters. This expertise, currently only available within MOD programmes, could be exploited in future civil noise mapping.

Recommendations

- 1) Academic research is required to better understand the human response to helicopter noise. In defining new approaches, the low incidence rate of most helicopter operations and the non-acoustic factors, also known as 'virtual noise', which encompasses community attitudes and fears towards the operations, should be considered.
- 2) Complaints should be collected and logged in a central database. This should embrace all sources including the CAA, the MOD, local authorities, operators and airfield managers. Attention should be paid to methods utilised in Australia where monthly reports on complaint statistics are provided to stakeholders.
- 3) Pilots should be made more aware of helicopter noise, perhaps during training for the Private Pilots Licence (PPL) or Basic Flying Training for the military pilot. Such a scheme, the HAI's 'Fly neighbourly' program, is successfully operated in the US, Germany and other countries. This can be part of the best practical means of minimising noise complaints.
- 4) Applied research is required so that land use planning guidance, such as PPG24 in England, can be revised. Specific land use planning guidance needs to be developed for the assessment of noise from helicopter operations.
- 5) Developers need to be encouraged to enhance sound insulation in new / change-of-use builds near helicopter bases.
- 6) For accurate prediction of environmental noise from helicopter operations, and for noise maps, data on the source noise of civil helicopters needs to be obtained.

¹CAP 724 Airspace Charter, November 2007 (Directorate of Airspace Policy, CAA).

Summary

I) Objectives

- 1) To investigate the reported adverse impacts of helicopter noise and to provide information on the nature and extent of the concern about helicopters noise in the UK.
- 2) Compile a summary of procedures in place for handling helicopter noise complaints and the roles, responsibilities and powers of the related authorities and organisations.
- 3) Compile a summary of the current rules and regulations governing helicopter operations, any current relevant industry codes of practice, and any existing reported dose response relationships.
- 4) Identify opportunities for improvement and make recommendations on how improvements could be implemented.

II) Methodology

The methodology used to complete these aims and objectives consisted of a worldwide literature search, a survey of stakeholders and a One-day meeting carried out under the auspices of the Institute of Acoustics. Key literature was identified by searching technical journals, conference proceedings, the internet, libraries, and through stakeholder contact. A telephone/email survey of stakeholders was conducted to investigate the extent of the concern about helicopter noise in the UK. Additionally stakeholders were asked about procedures for handling complaints, current rules and regulations, and industry codes of practice governing helicopter operations. Stakeholders were identified through the Defra technical working group, contact with the BHAB, contact with the MOD, contacts in local government and as a result of the literature review. Stakeholders identified and contacted included: helicopter operators; helicopter pilots, airport management, environmental health officers, public pressure groups, helicopter manufacturers, private consultants and emergency services amongst others. A One-day Meeting was held on the 6th February and all contacted stakeholders were invited. The IoA publicised the meeting and a good attendance was achieved. Speakers at the meeting included representatives from Defra, CAA, AgustaWestland, MOD, BHAB, QinetiQ and Wandsworth council. This provided opportunity for debate between key stakeholders.

III) Results – nature of the concern about helicopter noise

Social surveys indicate that helicopters can be up to 15dBA more annoying than fixed-

wing aircraft for the same or lower measured sound level. Studies attempting to relate dose-response with annoyance due to helicopter operations have produced poor correlation and have been broadly criticised. There is no straightforward relationship between objective noise and subjective annoyance. No good correlation with complaints has been found with LAeq, LCeq, LMax, L10 and LMax-L90. Studies addressing the noise from light aircraft and microlights reveal similar issues; that noise level may be a secondary issue and different indices may be required for low volume operations.

Reaction to helicopter noise is determined by acoustic and non-acoustic 'virtual' noise. Non-acoustic factors are thought to be of equal or greater importance and may be triggered by impulsive/tonal noise generated by the rotors. This means that addressing acoustic noise limits may be unlikely to significantly improve public acceptance of helicopter noise. 'Virtual' noise by factors other than noise including flight safety, privacy, soundscape, locus of control and mental health. Perceived effect on house price has also been shown to be a significant factor. Highest annoyance has been correlated with uncommon or exceptional helicopter events and complaints have been found to be more likely if the resident has a negative attitude towards the helicopter operator. It is suggested that the term annoyance does not fully describe the subjective response to helicopter noise and perhaps a multifactor approach similar to the approach of classifying work-related stress may be adopted. The following classifications, amongst others, may be important; intrusion, distress, startle, disturbance, locus of control.

IV) Results – extent of the concern about helicopter noise

The Chartered Institute for Environmental Health (CIEH) conducts an annual survey of environmental health departments but has only in the past two years started to record helicopter noise complaints. On average, for those two years, helicopter complaints make up about 5% percent of the overall number of noise complaints received from all transport, in 2005-2006 there were 45 individual complaints and in 2006-2007 there were 37. The CAA reports that there were 370 noise complaints resulting from helicopter operations in the UK in 2007, 80 of which were regarding helicopter

operations over London. RAF Shawbury reports receiving 313 noise complaints in 2007.

As a result of debate at the One-day meeting it was revealed that the ratio of helicopter movements to number of complaints received is generally very small for most operations. The consensus amongst stakeholders is that there is not a significant helicopter noise problem in the UK. However, problems do exist and these are centred on helicopter infrastructure such as specific heliports and aerodromes. However, this may simply be because complainers near to an airfield/heliport know who to complain to, whereas those that live further away do not.

V) Results – procedures for handling complaints, roles and responsibilities and noise reduction

The CAA acts as a focal point for receiving and responding to aircraft-related environmental complaints from the general public. However, the CAA does not have the legal power to prevent aviation activity on solely environmental grounds, except when considering changes to the structure of controlled airspace. An independent review is considering greater powers for the CAA over environmental matters.

The CAA encourages noise complaints to be made directly to the airport operator. However, this only works if the complainant knows where the helicopter is operating from/to. Problems related to noise generated on the ground at aerodromes, other than in association with the normal operation of aircraft, should be referred to the Local Authority. MOD complaints should be addressed to the base's community liaison officer or via the MOD complaints telephone line.

Consultative committees to enable dialogue between residents, councils and heliport operators have been shown to improve understanding and acceptance by the public. When operated successfully, the public appreciate that their concerns are being taken seriously. This is because they represent a neutral position from which to influence operators to change operational procedures. Consultation with the public in a number of instances has encouraged operators to make operational changes with a positive outcome for the complainants, examples include; establishment of voluntary avoid areas, circuit rotation for training flights and improved pilot awareness.

BHAB codes of practice aim to persuade the helicopter pilots and operators to take more notice of environmental noise issues.

Although pilots are aware of noise issues, factors such as safety are considered more important. Pilots should be made more aware of helicopter noise. This could form part of the training for the Private Pilots Licence (PPL) or Basic Flying Training for military pilots. This can be part of the best practical means of minimising noise complaints.

Helicopter noise certification does not take into account all aspects of noise from urban operations and the subjective problems caused by helicopter noise are not represented by the certification parameters. Manufacturers are concerned that a gradual reduction in the certification levels will compromise helicopter performance (or even refusal of type certification) while not addressing the public acceptability.

Two significant European projects address noise from helicopters, FRIENDCOPTER and the "Clean Sky" JTI. Both aim to produce a significant reduction in the noise generated by helicopters using new technology.

VI) Results – planning and prediction

The Planning Policy Guidance document (PPG24) lists a series of four Exposure Categories to help indicate whether planning permission should be granted for new housing near an existing source of aircraft noise. A residential planning application close to an operating heliport, when evaluated in accordance with PPG24 solely on the grounds of Leq, is unlikely to be rejected because of excess noise. This is because PPG24 Exposure Categories are based on Leq levels, which are not appropriate for intermittent noise events such as helicopter operations. The land use planning system offers an opportunity for the control of the noise impact of heliports but the current guidance is rather limited. PPG24 recommends Leq levels not be used to assess small operations (<30 movements/day), although an alternative method is not specified.

Noise maps and action plans are required by the Environmental Noise Directive on a five-year cycle. Helicopters are not excluded, though rudimentary noise mapping of helicopter noise is currently restricted to major airports. However, the accuracy of these strategic noise maps relating to helicopter noise is limited by the lack of sufficient metrological source data and validation of noise prediction models in this context.

The Lden is not an informative parameter for the depiction of helicopter noise, since helicopter noise arises from individual flights as opposed to the average of a large number of flights. Noise maps displaying Lden are therefore unlikely to be suitable for the prediction of community response to helicopter noise.

VII) Conclusions – nature of the concern about helicopter noise

Academic research is required to better understand the human response to helicopter noise. It is suggested that new or modified measurement indices need to be defined that address the unique subjective reaction to helicopter noise. In defining new approaches the low incidence rate of most helicopter operations and the non-acoustic factors or 'virtual noise' that encompasses community attitudes and fears towards the operations should also be considered.

VIII) Conclusions – extent of the concern about helicopter noise

Determination of the scale of public concern about helicopter noise would require a social survey. However, determination of a dose-response relationship for the prediction of community response to helicopter noise would need careful design and an extensive study. The study would need to take into account socio-economic and cultural factors, and the type of helicopter activity.

A repeated view expressed amongst stakeholders was that the scale of the problem of helicopter noise could not be estimated without the central logging of complaints. It was suggested that there is a need for a more "holistic" approach, and national statistics for helicopter noise complaints are required before an "informed debate".

There is consensus amongst stakeholders that there may not be a helicopter noise problem now but it has the potential to become one. Others suggested that perhaps the question should not be 'is there a serious noise problem in the UK?' but rather 'Are we facing increased opposition to the development of helicopter bases and operations, and if so, what are we going to do about it?'

IX) Conclusions – procedures for handling complaints / roles and responsibilities / noise reduction

Helicopter noise certification is not directed at urban operations and certification does not guarantee public acceptance.

Consultative committees can be effective in managing the public's concern about helicopter noise and help lobby operators to change operational procedures.

To ensure there is accountability related to environmental noise problems caused by helicopter operations, it is suggested that complaints are collected and logged in a central database from all sources including MOD, CAA, local authorities, operators and airfield managers. Attention should be paid to methods utilised in Australia where monthly reports on complaint statistics are provided to stakeholders.

A fast and sincere response is important in keeping complainants from becoming repeat complainers. The failure to act on complaints is one of the largest causes of dissatisfaction and resentment amongst the public.

X) Conclusions – planning and prediction

Developers need to be encouraged to enhance sound insulation in new / change-of-use builds near helicopter bases. Extending consultation to include developers may help to make developers more aware of the problem.

In England, the current land use planning guidance (PPG24) states that noisy and noise sensitive land uses should be kept apart. PPG24 provides advice to assist with the consideration of new residential development near existing sources of aircraft noise, but the guidance states that it should be used with caution where there is existing helicopter noise. PPG24 contains limited planning guidance on the noise impact of new heliports.

Applied research is required so that land use planning guidance, such as PPG24 in England, can be revised and specific assessment methods suggested for noise from helicopter operations.

Appropriate data on the source noise of civil helicopters, except where they overlap with military platforms, is not available, and needs to be collected and/or estimated through source prediction code as a matter of priority. The UK has world-leading expertise in helicopter noise prediction and in the measurement of source noise from helicopters due to involvement in military programmes. This expertise, currently only available within MOD programmes, could be exploited in future civil noise mapping.

Preface

This report presents work performed on behalf of Defra by the University of Salford and QinetiQ Ltd. However, we would like to thank the large number of people that assisted in this research and in the preparation of this report.

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1. Introduction

1.1 Background to the research project

1.1.1. Helicopter noise can have a negative impact on the quality of life for some people. Affected populations are not just those living close to heliports, but include those exposed to noise from helicopters used by emergency services, the military, commercial companies and private individuals. One problem identified is that it is often difficult to complain about helicopter noise since it is unclear which organisation is responsible for dealing with the complaint.

1.1.2. This research project was proposed by Defra with the objective of improving the management of noise from helicopter operations. This was due to a perceived lack of information in connection with helicopter noise, and in particular, with regard to whom complaints should be addressed. Clarification was also required on remediation and mitigation.

1.1.3. Current perceptions were supported by the recent London Assembly Environment Committee report, "London in a Spin – a review of helicopter noise October 2006". That report states that there is anecdotal evidence of a growing concern amongst members of the public about helicopter noise. The Department for Transport (DfT) is currently working with the Civil Aviation Authority (CAA) and National Air Traffic Services (NATS) in response to the key recommendations. This report for Defra, which also looks at procedures abroad, addresses many of the questions raised in the London Assembly report although the scope of this study is UK wide.

1.2. Policy context

1.2.1. The Environmental Noise Directive (END) 2002/49/EC [1] was published in the Official Journal on 18 July 2002. The aim of END is to provide a high level of health and environmental protection against noise.

1.2.2. The END requires Member States to make Strategic Noise Maps for major agglomerations (defined as areas of urban development with a population of at least 250,000, a population density of 500 person per square kilometre and a continuous urban area of at least 20 hectares) major roads, major railways and major airports within their territories.

1.2.3. As part of the END, Action plans designed to manage noise issues and effects including noise reduction if possible will have to be drawn up by 18 July 2008 and submitted to the Commission by January 2009. The airport authorities are responsible for drawing up action plans, which must be approved by the SoS. Action plans for other sources including agglomerations will be drawn up by the SoS. Public and stakeholders will be consulted.

1.2.4. Helicopters are not excluded from the Environmental Noise Directive but are only accounted for at major airports.

1.3. Aims and objectives

The aims of the project were:

- 1) To determine the issues and the extent of the reported problem of noise from helicopter operations in the UK.
- 2) To develop practical guidance on the management of helicopter noise, including improvements in the handling of complaints.

The objectives of the study were:

- 1) To investigate the reported adverse impacts of helicopter noise and to provide information on the nature and extent of the concern about helicopter noise in the UK.

- 2) To compile a summary of the existing procedures in place for handling complaints relating to noise from helicopters together with the roles, responsibilities and powers of the various authorities and regulating organisations.
- 3) To compile a summary of the current rules and regulations governing helicopter operations, any current relevant industry codes of practice and any existing reported dose-response relationships. Opportunities for improvement will also be reported and recommendations made on how these could be implemented.

1.4. Defra Technical Working Group

1.4.1. Defra formed an ad-hoc technical working group of key stakeholders to participate in and oversee this project. Their role was to advise Defra on information sources, current problems and possible solutions, and to peer review the project deliverables. The members of this technical working group are summarised in the table below.

Role	Name	Affiliation
Nominated Officer	Antonio Acuna	Defra
Chairman:	Richard Perkins	Defra
Project Manager	Ian Sherlock	Defra
Policy Officer:	Wendy Hartnell	Defra
Policy Adviser:	Stephen Turner	Bureau Veritas
Member	Colin Grimwood	Bureau Veritas (PPG24)
Member	Paul Freeborn	Bureau Veritas (BHAB)
Member	Darren Rhodes	ERCD / CAA
Member	James Deeley	ERCD / CAA
Member	Steve Mayner	Wandsworth Council
Member	Colin Stanbury	Wandsworth Council
Member	Christopher Forrest	PremiAir [BHAB]
Member	Roy Strapp	DfT (Aviation Environmental Division)
Member	Frank Evans	DfT (Aviation Environmental Division)

Table 1: Defra Technical Working Group - Helicopter noise

2. The Problem of Noise from Helicopter Operations in the UK

This section introduces the issues and the extent of the reported problem of noise from helicopter operations in the UK. The nature and the extent of concern about helicopter noise in the UK is presented. Objective measures and dose-response relationships are briefly described to facilitate a short overview of subjective responses. Current means of redress for any perceived disturbance caused are listed before an overview of the London in a Spin report. A short summary of the views elicited from stakeholders at an Institute of Acoustics meeting on this topic is presented as part of an estimation of the problem of helicopter noise. These issues are addressed in detail later in this report.

2.1. Nature of the concern about helicopter noise in the UK

2.1.1. Surveys suggest some people tend to be concerned about helicopter operations and the noise they create for a number of reasons. The main issues identified in this report are summarised as follows:

- 1) The subjective response to aircraft noise is often described in terms of community 'annoyance' and studies have indicated that helicopters can be up to 15dB 'more annoying' than other aircraft [3].
- 2) Sound levels alone do not account for annoyance trends in communities. People are also concerned about other aspects of the operations and the noise acts as a trigger for these concerns. Examples include concerns about safety, perceived intrusion of the helicopter into one's personal living space, and negative opinions towards the purpose of the flight [3].
- 3) Research (primarily concerned with fixed wing aircraft) has shown that noise adversely affects classroom learning. It has been shown that low achieving students are the most adversely affected [4].
- 4) High aircraft (fixed wing) noise levels can awaken people, but the likelihood of the average person having their sleep noticeably disturbed due to an individual aircraft noise event is relatively low [4]. However, sleep disturbance from helicopter operations may differ considerably due to its unique modes of flight such as hovering and low flying.

- 5) A recent study has shown that for every 10dB increase in night-time noise level for fixed-wing aircraft (L_{night} 2300 – 0700), the risk of hypertension is increased by about 14% [5].

2.2. Extent of the concern about helicopter noise in the UK

2.2.1. The CAA reports that there were 370 noise complaints resulting from helicopter operations in the UK in 2007, 80 of which were regarding helicopter operations over London [6]. However, this is not a complete list as complaints about military helicopter use and complaints directed at operators and local authorities are not included.

2.2.2. The London Assembly Environment Committee 'London in a Spin' report states that "anecdotal evidence from the public has indicated a growing concern with helicopter noise" [7]. The authors comment "there is no comprehensive database of helicopter movements across London, so it is impossible to tell the extent to which this noise nuisance has increased".

2.2.3. Anecdotal evidence reveals 'pockets' of complaints arising around areas such as busy heliports, aerodromes and some RAF bases. RAF Shawbury reports receiving 313 noise complaints in 2007.

2.2.4. The Chartered Institute for Environmental Health (CIEH) conducts an annual survey of environmental health departments but has only recently (in the past two years) started to record helicopter noise complaints. On average, for those two years, helicopter complaints make up about 5% of the overall number of noise complaints received from all transport; all transport being fixed-wing aircraft, motorbikes, cars and commercial vehicles (e.g. lorries, vans buses etc) [8].

2.3. Noise indices and measurement methods

2.3.1. In assessing the environmental impact of noise on individuals and communities, an objective descriptor with a well-defined relationship with community annoyance is required. Annoyance is complex and different individuals and communities react differently to different noise sources. A large number of indices have been developed for various applications. As this may lead to confusion and misinterpretation of data, a number of researchers have tried to move towards a standardised method of assessing aircraft noise [9] but have met with little success "because of the variability and unpredictability of reaction the impact of noise has always been difficult to quantify. As a result there is no single measure of the impact on the community of noise" [10].

2.3.2. Noise level is measured as sound pressure level in decibels (dB), a measure describing a sound level relative to the threshold of human hearing (in the mid frequency range). Sound level is often averaged over a period of time, and often frequency weighting scales are applied to sounds to take into account the human auditory response systems' uneven nature. The most commonly used frequency weighting system is A-weighting which is designed to model the human auditory frequency response at relatively low levels (<55dB). A-weighting was also found to correlate well with the human response over a wider range of sound pressure levels. There are also B, C and D weightings. B and C weightings were designed to account for the change in frequency response at different sound pressure levels of the human auditory system. The D weighting was introduced to account for the spectral characteristics of turbo-jet powered aircraft as an approximation to Perceived Noise Level (PNL) but is now obsolete.

	2005-2006	2006-2007
Number of Complaints	56	40
Number of Noise Incidents complained of	45	37
Nuisance Ceased and Not Likely to Recur	0	1
Referred to Other Services	6	1
Resolved Informally	11	1
No Action Possible	13	4

Table 2: Helicopter noise complaints received 2005-2007 (survey of Environmental Health departments) [8].

2.3.3. A wide variety of noise indices have been developed for use in aircraft noise and community response studies:

- Perceived Noise Level (PNL)
- Effective Perceived Noise Level (EPNL)
- Noise and Number Index (NNI)
- Australian Annoyance Index (AI)
- Disturbance Index (Q)
- Equivalent Continuous Noise Level (Leq)
- Equivalent Sound Level with Threshold
- Single Event Noise Exposure Level (SEL)
- Exposure Forecast
- Psophic Index
- Weighted Equivalent Continuous Perceived Noise Level (WECPNL)
- Day-Night Level (DNL)
- The 16h A-weighted Equivalent Continuous Noise Level (LAeq, 16h)
- Day Equivalent Continuous Noise Level (Lday)
- Evening Equivalent Continuous Noise Level (Levening)
- Night Equivalent Continuous Noise Level (Lnight)
- Day, Evening, Night Equivalent Continuous Noise Level (Lden)

2.3.4. In the UK, NNI was used from the government's Wilson committee report from 1963 until 1990, when the 1984 Aircraft Noise Index Study (ANIS) led to the LAeq being adopted as the UK aircraft noise index. However, just as the NNI has been dropped in the UK, so too has the Psophic index, the Dutch are about to drop the Kosten Index, and the Japanese are about to drop WECPNL. All are moving towards the use of Lden.

2.3.5. The 16-hour LAeq and night-time LAeq are used in planning legislation to determine whether planning application can be granted. Often noise levels are predicted to determine whether planning applications will be granted. As a result of the Environmental Noise Directive (END) (2002/49/EC), noise maps have been produced to identify noise climate and help develop action plans to manage noise levels. These maps show noise contours where each contour represents an average noise level. Lden is the 24-hr Leq calculated for an annual period, but with a 5 dB weighting for evening and a 10 dB weighting for night. Directive 2002/49/EC requires EU Member States to produce noise maps using the Lden noise metric, although helicopters are not currently included. The Lden is not an informative parameter for the depiction of helicopter noise, since helicopter noise arises from individual flights as opposed to

the average of a large number of flights. The situation is illustrated by figure 1.

2.3.6. Civilian helicopters must undergo a noise certification test for each type of craft. Heavy (>3175 kg) and light (\leq 3175 kg) helicopters have separately defined tests, although light helicopters may use the scheme for heavier helicopters. For heavy helicopters, noise levels are measured at three points on the ground during three prescribed flight conditions – take-off, level flight and approach to landing. The Effective Perceived Noise Level (EPNL) is used as a descriptor of the noise level. For light helicopters, certification is based on the flyover condition only and the sound exposure level is used to categorise the noise level. Both SEL and EPNL utilise only the highest 10dB of the noise event, however, sound outside this upper 10dB region can still cause annoyance, especially where high levels of impulse noise are present [3]. Since there is a discrepancy between noise target limits and public acceptance, the use of certification levels by manufacturers as design targets for acceptable noise performance may be problematic. It should be noted that although military helicopters are expressly excluded from noise certification, civil and military variants of newly designed aircraft are usually based on common rotor, engine and transmission systems so that the noise characteristics are virtually identical. It follows that military helicopters are designed to the same noise standards as civil aircraft. Chapters 4.7 and 3.8 refer in more detail to noise certification.

2.4. Existing dose response relationships

2.4.1. A dose-response relationship is a function that is designed to predict the relationship between an objective physical measure such as sound level, to a subjective response such as annoyance. The Aircraft Noise Index Study (ANIS), published by the CAA in 1984, aimed to accurately measure human responses to aircraft noise, and to find the dose-response relationship that best describes this subjective response. The result of ANIS was a dose-response relationship where the percentage of people who found the aircraft noise unacceptable increases from around 15% at 57dB LAeq roughly in a straight line to around 75% at 69dB LAeq. No equivalent study has been performed specifically for helicopters [11].

2.4.2. DORA published DR Report 8304: 1982 Helicopter Disturbance Study [112], although inconclusive, found that annoyance was greater from helicopter noise than for fixed-wing aircraft for a given noise exposure level. Another limited social survey was undertaken as part of the 1990s London Heliport Study [113] and is mentioned in that report. As a result of that work, helicopter noise contours were plotted down to 51dB LAeq 16hr (6dB lower), acknowledging greater annoyance from helicopter traffic. A separate helicopter social survey report was referenced to be published shortly after, but ultimately never appeared.

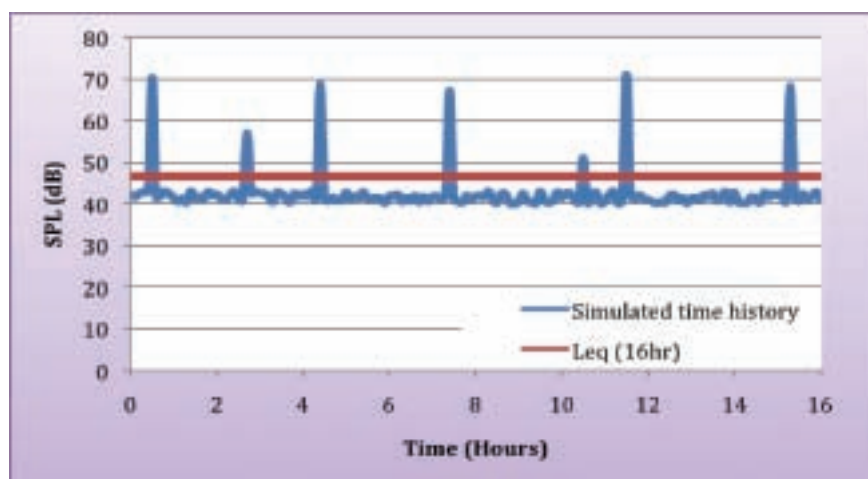


Figure 1: Simulated time history (SPL) of sporadic helicopter flyovers compared with 16hr Leq.

2.5. Subjective responses to helicopter noise

2.5.1. Most community response measures to acoustic stimuli are based on A-weighted sound pressure levels averaged over a long period of time. However, when dealing with only a small number of acoustic events, e.g. seven helicopter flights over a sixteen-hour period (see figure 1), the acoustic events have little bearing on the resulting measure. The United States FAA report [4] states the current measures are deficient for helicopters in terms of not only the number of events, but also in how the subjective effect is measured. In particular, low frequencies and the impulsive nature of sound are not accounted for in current metrics. The FAA acknowledges this problem in its 2004 report to the United States Congress but continues to use the Day-Night sound level (DNL) as there is no verified alternative.

2.5.2. In addition to these problems with measurement indices, studies have found that current objective metrics are not representative of annoyance, and that attitudes to the helicopter operations are a contributing factor. The term 'virtual noise' is used to describe non-acoustic factors such as fear of crashes and other negative views of the helicopter operations [3].

2.6. Means of redress for any perceived disturbance caused

2.6.1. The CAA acts as a focal point for receiving environmental complaints about aircraft. However, the CAA has no legal power to prevent aviation solely on environmental grounds. Unless there is clear evidence of a breach of the Air Navigation Order, the CAA will advise the complainant to contact the operator directly.

2.6.2. Often establishing communication and dialogue with helicopter operators can produce a positive outcome and an explanation of the purpose and nature of the operation that caused the disturbance can be satisfactory. Consultative committees have been found to be particularly helpful in raising issues with operators and ensuring operators are aware of their environmental impact. In addition, making the operator aware of problems caused can often result in changes to operational procedures to help alleviate the public disturbance.

2.7. London Assembly Environment Committee report, "London in a Spin"

2.7.1. In 2006, the Greater London Authority published a review of helicopter noise in London. The report highlights "concern among a number of groups of residents as to the impact of helicopter noise on their quality of life". The report comments that "helicopter movements have been growing over the past few years" and are a distinctive feature of urban living. The report makes a number of short-term practical recommendations to the Government and the Civil Aviation Authority (see chapter 9).

- 1) Develop a database to allow the public to monitor helicopter movements.
- 2) Develop robust complaints procedures to ensure the public's concerns are taken seriously.
- 3) Establish a consultative committee at the London heliport.
- 4) Changes to the way London's airspace are managed.
- 5) The possibility of a user charge for operators.
- 6) More effective write-down incentives for older, noisier helicopters.
- 7) Consideration should be given to moving the heliport to another location.

2.7.2. Use of the findings from the 'London in a Spin' report to highlight the "growing concern over helicopter noise" has been criticised as anecdotal evidence. This is because data was received from only 132 London residents. This is a small proportion of those currently subjected to noise from helicopter movements [2]. Since the report, and at least in part as a result of the recommendations, the following steps have been taken:

- 1) A consultative committee has been established at the London Heliport.
- 2) A complaints telephone line has been established at the London Heliport.
- 3) The CAA has initiated changes to airspace classification and designated helicopter routes to prevent helicopter holding.
- 4) The CAA has agreed a mechanism with NATS to provide helicopter movement data for the public on its website.

2.8. Estimating the scale of the problem of helicopter noise

2.8.1. On the 6th Feb 2008 an Institute of Acoustics meeting was held at the University of Salford entitled "The improvement of the management of helicopter noise". One of the aims of the meeting was to try to collect information by engaging major stakeholders in structured discussion. One of the results of the debate was that it appears the ratio of helicopter movements to number of complaints received is generally very small for most operations. A repeated view was that the scale of the problem of helicopter noise could not be estimated without the central logging of complaints. It was suggested that there is a need for a more "holistic" approach, and national statistics for helicopter noise complaints are required before an "informed debate".

2.8.2. An important point raised was the need to be cautious in using complaint statistics as a measure of the problem. While many complaints are from repeat complainers, not everyone that is disturbed complains. Furthermore, with relatively few numbers of complaints received about helicopter noise, a statistically meaningful result is difficult to derive.

2.8.3. Another suggestion to estimate the scale of the problem involved carrying out a national public survey. A point raised was that "canvassing opinion may raise the profile of the problem and aggravate it". However, social survey techniques exist to avoid this problem.

2.8.4. A generally common view from delegates was that the question of whether or not helicopter noise is a "problem" still needs to be determined; there does not seem to be enough evidence at present to answer this question. Recorded views included: "Although there is an argument that it may not be (a problem) now, I feel it certainly has the potential to become one" and "perhaps the question should not be 'is there a serious noise problem in the UK?' but rather 'Are we facing increased opposition to the development of helicopter bases and operations, and if so, what are we going to do about it?'

2.8.5. General consensus among stakeholders is that there is not a significant helicopter noise problem throughout the UK. However, problems do exist and these are centred on helicopter infrastructure such as heliports and aerodromes.

2.9. Summary of Chapter 2

2.9.1. Problems due to helicopter noise are centred on helicopter infrastructure such as heliport and aerodromes. The ratio of helicopter movements to number of complaints received is generally small for most operations. The Chartered Institute for Environmental Health (CIEH) reports that helicopter complaints make up around five per cent of the noise complaints received from all transportation. The CAA reports that there were 370 noise complaints resulting from helicopter operations in the UK in 2007. However, there is no comprehensive database of helicopter movements in the UK. Consequently, it is impossible to determine the extent to which noise nuisance is a growing concern.

2.9.2. Helicopters can be up to 15dB more annoying than fixed-winged aircraft. However, sound levels alone do not account for annoyance trends in communities from helicopter noise. There is no single satisfactory noise index for the measurement or prediction of the impact of noise on the community. The use of certified levels as design targets for acceptable noise performance is likely to be problematic, since there is a discrepancy between noise target limits and public acceptance.

2.9.3. The Lden is not an informative parameter for the depiction of helicopter noise, since helicopter noise arises from individual flights as opposed to the average of a large number of flights. Noise maps displaying Lden are therefore unlikely to be suitable for the prediction of community response to helicopter noise. It is widely recognised that while Leq or Lden are not ideal, currently there is not a better option. Further research is required to develop a dose-response relationship to accurately measure human response to helicopter noise.

3. Helicopter operations in the UK

This section considers helicopter operations in the UK. An introduction to helicopter noise generation mechanisms is given, together with noise reduction methods relating to these mechanisms. The helicopter operations of the emergency services, including the police, air ambulance and search and rescue are outlined, followed by military and civilian operators. Finally, explanations of helicopter infrastructure, helicopter routes and noise certification are presented, together with comparisons as appropriate to those of fixed wing aircraft.

3.1. Helicopter noise generation and reduction methods

3.1.1. Helicopter noise generation differs from fixed wing propeller driven aircraft because the main rotor and tail rotor operate close to the horizontal plane and vertical plane, respectively, with axes of rotation normal to the flight direction. Whilst for propeller driven aircraft the axis of the propeller is aligned to the direction of travel, and the noise from each propeller generally has symmetry about this axis. Such axial symmetry does not exist for helicopter rotor blade noise sources. For this reason very few of the helicopter noise sources are similar to that of its fixed wing counterparts [12].

3.1.2. Helicopter noise is generated from a number of main sources: engine noise, rotor noise and transmission noise. Apart from piston engine powered craft, the main noise sources are from the rotors [3]. Spectral analysis of helicopter noise reveals a series of tones generated by the main and tail rotors. The main rotor generates a series of tones whose fundamental is in the range 10 to 40Hz. The tail rotor generates a higher frequency tone series whose fundamental is usually in the range 100 to 200Hz [13]. Although the tonal noise dominates, broadband noise from both the tail and the main rotors is present at a lower level. There also exist interactive effects between tail and main rotors and the fuselage, the former interaction leads to combination tonal frequencies known as 'Burbles'[14]. Impulsive sounds also result from the blade tips intercepting the vortex from a preceding blade (Blade Vortex Interaction - BVI) or the vortices from the main rotor being intercepted by the tail rotor (Tail Rotor Interaction - TRI). In addition there exists high speed impulsive (HSI) noise

generated by transonic flow on advancing blades [13]. It is because of the high speed of the advancing rotor tips in comparison with the speed of sound in the medium (air) that the noise output is often directed ahead of the helicopter rather than behind it [13].

3.1.3. Helicopters differ from fixed wing aircraft since the primary noise generation mechanisms are also the primary lift and control mechanisms. For this reason, the realisation of a quiet helicopter must be fully integrated within the design process. Reduction in noise level is generally at the expense of performance factors such as payload, range and speed. The relationship between the helicopter design parameters is very close. For example, reducing the rotor tip speed will reduce the noise level however to maintain performance the blade area/number/shape would have to be altered [3]. This procedure was adopted in the development of the EH101/Merlin helicopter [15] the exceptional advancement in performance of the British Experimental Rotor Program (BERP) blade was partly traded for noise, by reducing tip speed, to produce the quietest helicopter in its weight class. Blade tips can be used to control BVI, see for example the vane tip programme [3]. Reducing tip speed can be effective but usually for a loss of performance and care is needed to prevent retreating blade stall for the lower speed.

3.1.4. Currently practical design improvements aim to reduce BVI and tail rotor noise. These are perhaps the biggest source of complaints regarding helicopter noise and the main trigger for non-acoustic factors or 'virtual noise'. Currently active and passive methods are being tested, and results have indicated varying degrees of success. Given sufficient development, a reduction of 6dB(A) in this area is foreseeable. Modifications to reduce BVI noise would not impact during noise abatement procedures and level flight [3] but tail rotor noise is present in all flight conditions and is a significant trigger of 'virtual noise'.

3.1.5. Tail rotor noise, because of its higher frequency content than main rotor noise, has a significant effect on the subjective perception of helicopter noise. A number of manufacturers have

embarked on design initiatives addressing this, including the Westland Helicopter's quiet tail rotor (Q.T/R), the McDonnell Douglas NOTAR, and the Eurocopter's fenestron fan-in-fin approach [3].

3.1.6. Following a study conducted by Leverton for Bell Helicopter Textron [3] it was recommended that the Mach number of the advancing blade tips should not exceed 0.875, and should generally be kept at less than 0.85 to prevent the impulsive sound becoming unacceptable.

3.1.7. As the temperature decreases, the speed of sound decreases, and therefore the Mach number increases. This results in a dramatic increase in the perceived magnitude and impulsiveness of the main rotor thickness noise close to the rotor disk plane. Helicopter manufacturers often provide noise data at the ICAO certification specified temperature of 25°C. The possible significant variation in level and subjective character of the helicopter noise due to temperature differences is not taken into account, and as such, some noise abatement operational procedures are not achieving the noise levels predicted. This is a particular problem for helicopters with high tip speeds and unsophisticated rotor designs. One manufacturer has recently introduced flyover speed limits where temperature is taken into account, and another two have indicated that they intend to follow suit. [3]

3.1.8. Operational procedures can help reduce the environmental impact of helicopters. Type specific Aircraft Flight Manuals (helicopter) contain a performance graph that details flying procedures to produce the least amount of noise although the flight envelope is difficult to follow due to the variety of power and airspeed configurations. A reduction in speed of just 10 knots can have a significant noise reduction effect [16].

3.2. Emergency services

3.2.1. Police: The UK police service fund their own helicopter operations [17]. The different forces will either buy or lease the helicopter, and use either their own staff or pay a third party, such as PremiAir or Sterling Helicopters Ltd, to operate the helicopter. Many police forces have recently upgraded their fleets with quieter

helicopters such as the McDonnell Douglas NOTAR equipped MD902, and the Eurocopter EC135 with its fenestron tail rotor. Currently the EC135 is the most popular police helicopter, followed by the MD902. These helicopters are some of the quietest available [16]. The proportion of different helicopter models in the police force in the UK is indicated in Figure 2. Police helicopters operate from a range of locations including RAF airfields, private general aviation aerodromes, major airports and bespoke landing sites.

3.2.2. Air ambulance: Air Ambulance Services operate as charities and rely on the public for funding. A survey by Morepace revealed that only 40% of the UK public is aware of this fact [19]. 16 regional charities support 26 air ambulances in the UK. In Scotland, however, the Scottish executive funds air ambulances, whilst in London air ambulance receives partial NHS funding. Figure 3 describes the break down of the different helicopter models operating as air ambulances in the UK. The Association of Air Ambulance Charities (AAAC) supports the work of the UK's independent air ambulance charities. The air ambulances undertake 17,500 missions in a year of which 40% involve road traffic collisions, 24% are other medical emergencies and 3% are hospital transfers[20].

3.2.3. Search and rescue (SAR): Search and rescue in the UK (on land and at sea) is covered by six RAF Search and Rescue teams, four civilian coastguard teams operated by the Maritime and Coastguard Agency (MCA), while the Royal Navy operates two SAR teams[21]. Before December 2005 the Maritime and Coastguard Agency contracted Bristow's Helicopters Ltd to operate 3 Sikorsky S61N helicopters and bases of operations are Sumburgh Airport (Shetland), Stornoway (Isle of Lewis) and Lee-on-Solent. All are capable of the full range of airborne search and rescue tasks. A fourth S61N helicopter stationed at Portland (near Weymouth) can operate in daylight only[22]. Announced in December 2005 CHC is now contracted to operate two S-92s at Stornoway and two S-92s at Sumburgh, plus two AB139s based at Lee-on-Solent and an additional AB139 at Portland [23].

3.3. Military helicopter operations

3.3.1. Almost all complaints generated by MOD helicopters will arise from low-flying operations. MOD low flying operations are comprehensively summarised in annual reports [24]. Low flying timetables for upcoming months are also published on the MOD's website.

3.3.2. The MOD divides the country into 20 Low Flying Areas (LFAs) as shown in Figure 4. Statistics on the distribution of military helicopter flights across the UK are then divided according to these areas.

Four of these areas are referred to as Dedicated User Areas (DUAs) where most of the helicopter pilot training takes place. These are areas 1, 3, 9 and 10 on the map. LFA1 contains RAF Odiham, home to Chinook and Lynx, and RAF Benson, home to Merlin and Puma. LFA3 contains RNAS Culdrose, home to Merlin and Sea King. LFA9 contains the Defence Flying Training School at RAF Shawbury, which runs pilot training on Gazelles, Griffins and Squirrels. LFA10 contains the Army Air Corps. at Wattisham, home to Apache and Lynx.

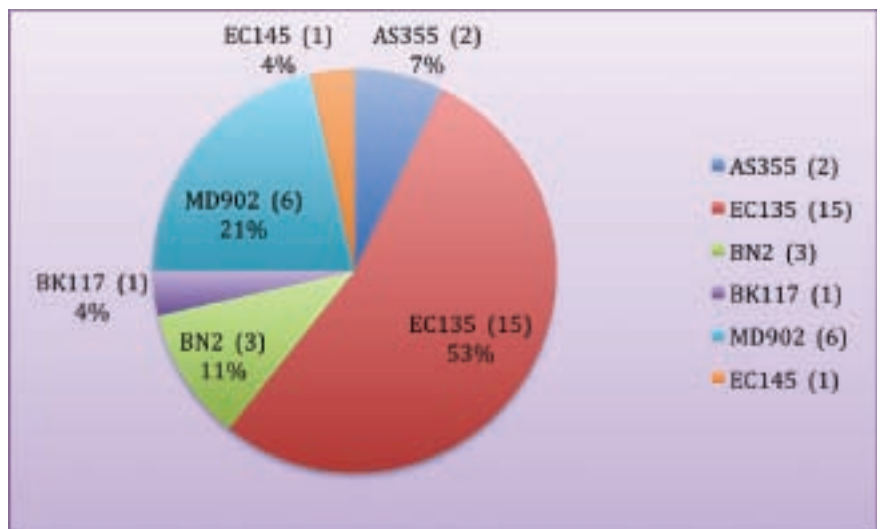


Figure 2: Breakdown of Police helicopter types[18]

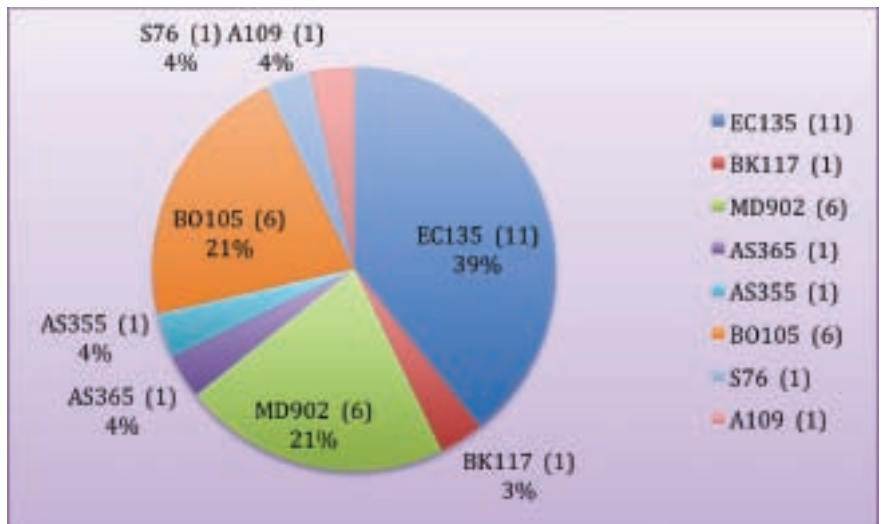


Figure 3: Breakdown of Air Ambulance helicopter types[18]

3.3.3. It should be noted that military helicopters do not have to meet the civil noise certification standard unless they are also used for civilian purposes. However, variants are often used for civilian applications in which case civil certification is required and as mentioned in 2.3.6, military and civil aircraft are usually based on common rotor, engine and transmission systems so that the noise characteristics are virtually identical.

3.3.4. Helicopters outside of Dedicated User Areas (DUAs) are considered to be low flying below 500ft, but in DUAs (because of the increased number of flights) any flight below 2000ft has to be recorded as a low flying activity. In 2006/2007 there were 16,164 hours of flying recorded outside of the DUAs, and 26,041 hours of flying recorded in the four specified DUAs.

3.3.5. There are 14 major areas in the country that the MOD cannot use for low flying. These predominantly lie around airports and large built up areas. In addition, towns with more than 10,000 inhabitants are avoided and anyone is eligible to apply to the MOD for an additional avoidance area.



Figure 4: Low flying areas for military aircraft. (LFA1 highlighted)

3.4. Civilian helicopter operations

3.4.1. Figure 7 indicates a steady increase in the number of civilian helicopters operating in the UK from 2002. These currently number 1,393[19]. There has been a particular increase in the number of smaller piston engine craft and this increase appears to be due to the recent popularity of the Robinson R22 and R44 helicopter.

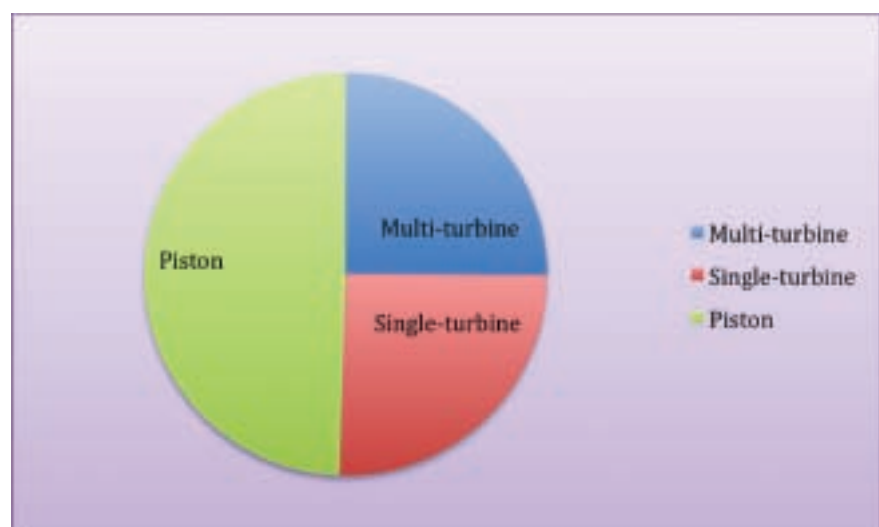


Figure 5: Break down of civilian helicopter types [19] Data from BHAB handbook
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Types of operations include:

- 1) Flights that take place during major sporting events (e.g. Goodwood Revival, British Grand Prix, Royal Ascot) and other major events such as the Farnborough air show.
- 2) Traffic surveillance.
- 3) Transporting heavy loads into inaccessible places (e.g. National Parks).
- 4) Pleasure flights.
- 5) Charter.
- 6) Transfers between airports / commercial premises.
- 7) Private owners.
- 8) Pipe line / power line surveying.
- 9) Scheduled services (e.g. Penzance to Isles of Scilly).
- 10) Servicing oil fields (e.g. Aberdeen).
- 12) Corporate flights.
- 13) Press / Aerial photography.

3.5. Helicopter infrastructure

3.5.1. When compared with fixed wing aircraft with a similar personnel capacity, the fixed wing aircraft is faster and cheaper in terms of capital and operating costs. The advantage of the helicopter is that it does not require a large amount of space from which to take off and land. This means that helicopters do not require the extensive infrastructure needed by fixed wing craft, and this enables the helicopter to offer virtually door-to-door transportation [25].

3.5.2. Helicopter landing / take-off sites: For ground level sites it is not possible to specify general requirements as all helicopters have different performance characteristics. A flat area around 24x16m should be sufficient for smaller types. Additionally, there should be no immediate obstructions after take-off and if possible, helicopters should be able to take off into the prevailing wind. It is the pilot's responsibility to ensure that the landing site meets the craft's specifications. When operated from elevated sites, such as rooftops, helicopters must meet more stringent safety requirements. For a craft to be able to operate from an elevated site, it must be certified Group A/ Class 1 by the CAA. This means that even if one engine fails, the craft is able to land or fly away safely using the remaining engine thus only twin-engine craft can operate from elevated sites [25].

3.5.3. Helicopters can operate from permanent landing sites such as heliports or aerodromes, and temporary landing sites such as fields, gardens and commercial premises. Refer to section 4.3 for details on planning permission for the different types of landing sites.

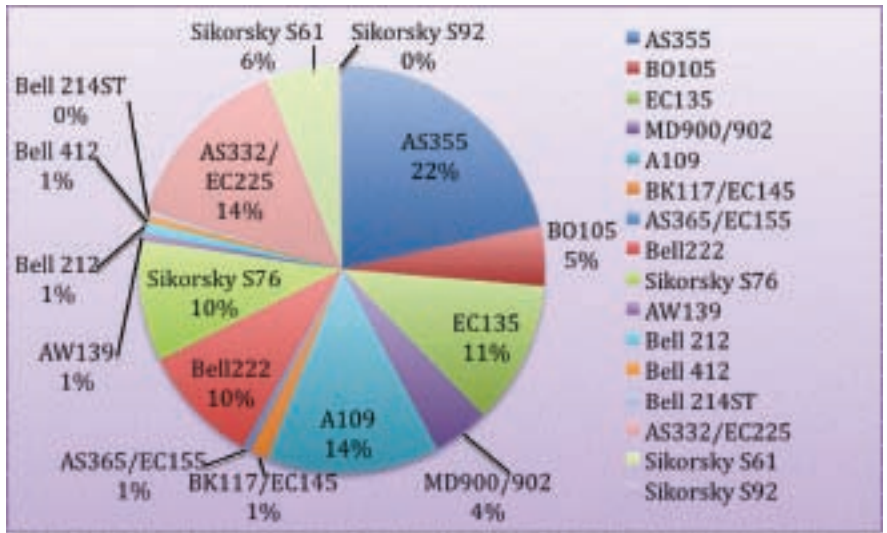


Figure 6: Break down multi-turbine civilian helicopter types [19] Data from BHAB handbook Copyright 2007 Computair Consultants: email info@computairconsultants.com.

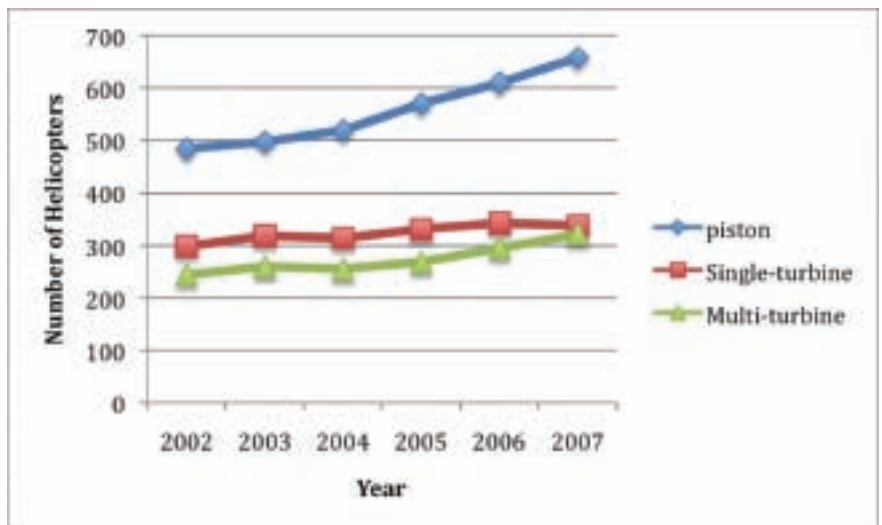


Figure 7: Recent trends in helicopter types [19] Data from BHAB handbook Copyright 2007 Computair Consultants: email info@computairconsultants.com.

3.6. Helicopter airspace restrictions

3.6.1. UK air space can be categorised as 'Controlled Airspace' (CAS) or 'Uncontrolled Airspace' (UCAS). Within controlled airspace, pilots must gain Air Traffic Control (ATC) clearance and comply with instructions issued. Controlled Airspace can be further categorised as follows [25, 26]:

- 1) Control zones are regions extending from ground level up, and span up to 2_ nautical miles from an aerodrome's datum.
- 2) Control areas are regions, which extend from approximately 2000ft and 5000ft upwards.
- 3) Airways are corridors that are the main routes connecting major airports.
- 4) Terminal control areas are larger control areas situated around groups of airports where major routes converge.
- 5) Upper airspace is the airspace from 19500 ft upwards.

3.6.2. The majority of air space in the UK below 2000ft is unrestricted (UCAS). Although there is no requirement for helicopter pilots to make contact with ATC when flying in UCAS, they often do so in the interest of safety. Helicopter pilots must comply with ATC instruction in control zones around aerodromes.

3.6.3. There are relatively few areas of restricted airspace over mainland UK. Examples include: areas of high-density military activity, atomic reactors, high security prisons and the residence of the Prince of Wales. In addition, temporary restricted areas can be set up for major incidents/accidents, temporary helicopter landing sites and temporary hazards to aviation. Surprisingly, some military danger areas and airfields are not necessarily restricted and only the CAS rules apply. Nevertheless, intentional intrusion without prior clearance is ill advised [25].

3.6.4. In addition to these rules of UK airspace operations, the rules of the air as described in section 4.1 also impact on airspace restrictions. Refer to this section for further information.

3.7. Helicopter routes

3.7.1. A number of helicopter routes have been established, usually to help air traffic control at busy airports. The primary function of helicopter routes is to maintain separation from fixed wing aircraft. They are designed so that helicopters will fly over open spaces whenever possible. Routes are designed to help helicopter pilots obey the Air Navigation Order (ANO) rules. Routes are not mandatory but in practice, especially in London, are generally followed (though twin engine craft can request to route direct). The report 'London in a Spin' contains a map showing the location of the helicopter routes in London [7].

3.8. Helicopter noise certification

3.8.1. All civil helicopter types in the UK require a certificate of airworthiness. Part of the certification requires noise certification. This is to ensure the craft meets certain internationally agreed noise standards set by the International Civil Aviation Organisation (ICAO) of which the UK is a member. The certification process is described in more detail in chapter 4.7. On the 28th March 2007 the European Aviation Safety Agency (EASA) initiated changes relating to the noise certification, which introduced an EASA Certificate for Noise (EASA Form 45) and set down standard values upon which each Certificate should be issued. The CAA has commenced a programme of replacing all CAA Noise Certificates for applicable EASA aircraft with Form 45 and this is targeted for completion by March 2009 [27].

3.9. Summary of Chapter 3

3.9.1. Helicopter routing is generally designed to assist Air Traffic Control and to maintain separation from fixed wing aircraft. In general, helicopter routes are designed to fly-over open spaces wherever possible.

3.9.2. The choice of rotor blade tip speed and to a lesser extent blade tip shape, is important because it controls the intensity and character of the impulsive noise generated by a helicopter. This applies to both the main and tail rotors.

3.9.3. 3.9.3. The largest non-military user of helicopters in the UK provides transportation for the oil and gas industry.

3.9.4. The majority of helicopters used by the Police and by the Air Ambulance Service are the quietest types available.

4. Rules and regulations relating to Helicopter operations

This section provides a summary of the rules and regulations applicable to helicopter operations and helicopter infrastructure in the UK. It refers to the Rules of the Air Regulations, relevant sections of planning and nuisance law, and to the codes of practice and guidance provided by the British Helicopter Advisory Board (BHAB) and the Civil Aviation Authority (CAA). This section also includes explanations of helicopter routes and noise certification. Finally, comparisons are drawn with rules and regulations from other European countries, the USA and Australia.

4.1. Rules of the Air Regulations

4.1.1. The conduct of civil aviation is set out in the Civil Aviation Act (1982). The Air Navigation Order (ANO) is the document that delegates powers to the Civil Aviation Authority (CAA). The ANO details exact specifications on all aspects of aircraft behaviour. Safety is the primary focus of the ANO [25].

4.1.2. Specifically, civilian helicopter flights in the UK are governed by the Rules of the Air Regulations 1996 [28] and the Air Navigation (Restriction of Flying) (Specified Area) Regulations 2005 [29].

4.1.3. The ANO and Rules of the Air Regulations permit helicopters operated on behalf of the police to fly lower than would otherwise be normally permitted.

4.1.4. Military operations do not operate under the ANO or the rules of the air regulations. Rather, they operate to Ministry of Defence regulations detailed in Joint Service Publications (JSPs). The CAA has no jurisdiction over military operations and all enquiries about these operations should be directed to the Ministry of Defence [30].

4.1.5. The ANO has three priorities

- 1) No aircraft may be operated in such a way that, even if an engine fails, third parties on the ground are put at risk.
- 2) If there are fare-paying passengers on board an aircraft, the operator is required to ensure that certain mandatory safety standards are met to ensure that risk of injury to the passengers is minimised.

- 3) In the case of private pilots, the CAA ensures that minimum standards in respect of flying, training, licensing, construction and maintenance are met.

4.1.6. The CAA has no legal power to prevent aviation on solely environmental grounds. Any breach in the ANO is referred to the Aviation Regulation Enforcement Department (ARED). The CAA can only act in the event of a breach of the ANO. To prosecute, a number of independent witnesses and positive identification of the aircraft are required [6].

4.1.7. An independent review is considering greater powers for the CAA over environmental matters [Frank Evans, DfT, IoA meeting].

4.2. Rules and regulations governing low-flying helicopter operations (ANO)

4.2.1. The ANO states "An aircraft shall not be flown below such height as would enable it, in the event of a power unit failure, to make an emergency landing without causing danger to persons or property on the surface".

4.2.2. Unless a helicopter is taking off or landing, in accordance with standard aviation practice, no helicopter may fly closer to a person, vehicle, vessel or structure than 500 ft (often referred to as the "500 foot rule"). This does not refer to absolute height and therefore helicopters can fly lower over moorland, for example.

4.2.3. No helicopter may fly over towns or settlements at a height less than 1500ft or within 2000 ft of the highest fixed object. This rule was amended in 2004 and the minimum height reduced to 1000 ft [28] (referred to as the "1000 ft rule").

4.2.4. Exemptions from both the 500ft and 1000ft rules are allowed with written permission from the CAA. Examples of exceptions include landing sites in city centres, aerial photography and police and ambulance services.

4.2.5. The 1000ft rule does not apply within controlled airspaces such as the London control zone and around aerodromes where air traffic control provides a control service to aircraft.

4.2.6. No flying over the centre of London, except over the Thames, unless the helicopter can fly even in the event of an engine failure. ("Specified Area rule"). Essentially this allows twin engine craft to fly over London where single engine craft must follow the Thames.

4.2.7. No flights are permitted over or within 3000ft of gatherings of people of 1000 or more without the permission of the CAA (referred to as the "crowd rule").

4.2.8. A blanket exemption exists regarding flights with the purpose of saving life.

4.3. Relevant sections of planning law

4.3.1. Permanent landing sites are generally regarded as those that have a CAA licence and that have been given planning permission by the local authority. There are only three licensed heliports in the UK, at Battersea, Penzance and Culter Helipad near Aberdeen [31]. For scheduled services to operate the heliport must be licensed. Helicopters can land at most fixed wing airfields both licensed and unlicensed. However, as helicopter flights should not cross fixed-wing aircraft landing and take-off paths, helicopter approach and departures at fixed-wing airfields are side-on to runways and are more likely to impact on properties less affected by fixed-wing operations.

4.3.2. Temporary landing site use is allowed as long it is not in use for more than 28 days in the year and permission is gained for its use. (Part 4, Class B of Schedule 2 of the Town and Country Planning General Development Order 1988). Local authorities have powers to withdraw the right to use the site, and to require a planning application to be made for continued use. If the direction is to remain in force for more than six months, approval from the Secretary of State for the Environment is required. If planning permission is refused or granted subject to conditions, compensation may be payable.

4.3.3. Helicopters may operate from private gardens of a property without planning permission. However, to use an adjoining field, even if it is also owned by the property owner requires either planning permission or use as a temporary landing site for up to 28 days per year. One issue raised was that the 28 days applies to a specific parcel of land and that a further 28 days would be allowable on an adjacent parcel of land [32].

4.3.4. Planning permission is not required for helicopter operations from commercial properties unless the size of the helicopter operation overtakes the size of the original business. In this case, planning permission must be sought.

4.3.5. Any landing site in urban and congested areas requires the prior written permission of the CAA before they can operate.

4.3.6. In 1963, the Wilson report led to the use of the NNI (Noise and Number Index) and defined 35 NNI as low annoyance and 55 NNI as high annoyance.

4.3.7. In the early 1980s, the CAA's Directorate of Operational Research and Analysis (DORA) carried out a study commissioned by the Department of Transport into the use of the NNI. The NNI was considered 'out of line' with aircraft noise nuisance indices used in other countries, which tended to use Leq based measures. This study became known as the Aircraft Noise Index Study (ANIS)[11].

4.3.8. ANIS revealed no 'hard statistical evidence for an 'N' variation in disturbance as compared with the log N of NNI and Leq' and 'If there is any variation with N, then it has a much smaller coefficient than the log N term over a very wide range of L and N values'. It was also demonstrated that the Leq measure correlated better with annoyance than NNI[33].

4.3.9. In the original planning documents (e.g. Circular 10/73), the criteria for annoyance were low/medium/high, and the NNI index was used as the index of annoyance. In the Planning Policy Guidance document (PPG24) [34], a series of four Noise Exposure Categories (NEC) called A, B, C and D based on LAeq levels are provided as guidance on the suitability of land for new residential development near existing sources of aircraft noise. Category D means planning should normally be refused. Category C indicates a strong presumption against acceptance unless there are no acceptable alternatives; in this situation, conditions should be imposed to ensure adequate noise insulation. Category B indicates that noise should be taken into account in the planning process and noise insulation is required. Category A indicates that noise is not a factor to be taken into account in the planning process. Exposure Categories can be used to determine whether planning permission should be granted to a new development in an area with existing noise sources. It is stated however, that they cannot be applied in the reverse context. LAeq levels for any category may be increased by up to 3 dB if there is a clear need for new residential development.

4.3.10. PPG24 recommends that where an aerodrome operates less than about 30 movements a day, Leq should not be solely relied on. PPG24 states, "when determining a planning application for a heliport the predicted noise should not be assessed in isolation - account should be taken of local circumstances including the existing level of noise disturbance". The document recommends that, due to the noise characteristics of helicopters, the noise exposure criteria should be treated with caution. Planners may request that the applicant discuss with NATS the establishment of helicopter routes if these are not supplied with the application.

4.3.11. When individual night-time noise events exceed 82 dB LAmax several times in any hour, the NEC should be treated as being category C, regardless of the LAeq,8h (except where the LAeq,8h already puts the site in NEC D). site in NEC D).

4.3.12. When a planning application close to an operating heliport is sent to appeal, PPG24 will be cited as a benchmark. Generally, it is unlikely that the LAeq noise levels alone will result in a rejection of the application. Consequently, Local Authorities should be aware of the provision within PPG24 for consideration of aviation noise for low numbers of movements such as helicopter operations.

4.3.13. In 2001, the Department for Transport commissioned a study intended to "underline the government's commitment to underpin our policy on aircraft noise by substantial research that commands the widest possible confidence". The results were presented in November 2007 as the 'Attitudes to Noise from Aviation Sources in England' report (ANASE) [35], and concluded that people were becoming increasingly annoyed by aviation noise. However, the report's findings were rejected following rigorous peer reviewing [36] [37] [38]. It should be noted however that the study relates to annoyance from fixed wing aircraft rather than helicopters.

4.4. Nuisance law

4.4.1. If aircraft operations meet the requirements of the ANO then persons are precluded from prosecuting based on nuisance (Civil Aviation Act 1982 section 76). Licensed heliports cannot be prosecuted under nuisance law as long as ANO requirements are met (Civil Aviation Act 1982 section 77). In addition heliports are specifically excluded from prosecution due to noise and vibration caused by helicopters landing and taking off, moving over ground or water and engines being operated in preparation for or after a flight for performance and maintenance reasons. (Civil Aviation Act 1982 section 78 + ANO reg 12 (general)). The Environmental Protection Act (1990 Part III section 79) defines a statutory nuisance caused by noise to be; 'noise emitted from premises so as to be prejudicial to health or a nuisance'. However subsection 6 says that this 'does not apply to noise caused by aircraft other than model aircraft'. Therefore aircraft, including helicopters, are specifically excluded from having action taken against their operators in respect of statutory noise nuisance.

LAeq,T(dB)	A	B	C	D
07:00 – 23:00	<57	57-66	66-72	>72
23.00 - 07.00	<48	48-57	57-66	>66

Table 3: PPG24 criteria for air traffic showing LAeq(dB) for each category for differing times of day

4.5. Helicopter Operations: Codes of practice

4.5.1. Operators often use Standard Operating Procedures (SOPs) that tend to include noise abatement procedures. PremiAir, the London Heliport operator, commented that they actively try to ensure that pilots fly in an environmentally friendly way as possible.

4.5.2. Airfield management may also establish 'avoid' regions and other noise abatement procedures. For example, at Birmingham International Airport, in response to a number of complaints received via the airport consultative committee, a region of avoidance and a minimum height recommendation were established. This was established by consultation between the ATC, the police operation at the airport, and the environmental department. Operations are able to breach the rule but are encouraged to stick to the recommendations. Since implementing the rule, the number of complaints has decreased.

4.5.3. Pilots are aware of noise issues but it is not always a priority concern. From a pilot's perspective, the most important factors considered for a pilot are: how to get back on the ground, with greatest ease, safety and economy.

4.6. Guidance provided by the British Helicopter Advisory Board (BHAB).

4.6.1. The BHAB provides codes of practice for helicopter pilots and operators. Codes of Practice have been defined to inform potential clients of some important basic facts concerning the commercial operation of helicopters. The aim is to ensure that high standards of safety and professional competence are maintained throughout the industry. The Code of Practice has been endorsed by the BHAB's Council of Management following consultation with the Civil Aviation Authority.

4.6.2. The BHAB are actively addressing the noise issue with the Noise Action Group (NAG). The aims of this group are to persuade pilots to take more notice of environmental noise issues and to lobby manufacturers to produce quieter helicopters. The group has members including senior people from various helicopter operators.

4.6.3. The BHAB handbook details general codes of conduct for pilots aimed at showing an environmentally conscious public that helicopter operators are aware of the need to preserve the environment from unnecessary noise intrusion. The BHAB handbook also details guidelines for operations in national parks, and carrying out aerial photography, and similar work over congested areas

4.6.4. The BHAB makes a number of recommendations to ensure operators and users minimise their environmental impact. These include[39] careful selection of the location of helicopter landing sites, sensible flight planning which includes environmental impact as a factor, taking into account the meteorological forecast and air traffic requirements and pilots flying in accordance with the BHAB's 'Pilots' Code of Conduct'.

4.7. Helicopter civil noise certification

4.7.1. Noise certification for helicopters was added to Annex 16 of the Convention on International Civil Aviation in 1981 by the ICAO (International Civil Aviation Authority) [40]. The procedures follow closely those established for certifying fixed wing aircraft. For heavy helicopters (>3175 kg) the certification process is defined in ICAO Annex 16 Chapter 8. Light helicopter certification is defined in ICAO Annex 16 Chapter 11. Chapter 11 is voluntary on the applicant, whether they choose to demonstrate compliance with Chapter 11 or stay with Chapter 8. A very small number of helicopters have been certificated using both Chapters.

4.7.2. Heavier helicopter certification uses three flight procedures: takeoff, overflight and approach, all of which are measured at three microphone positions. The helicopter performs each of the three procedures a minimum of six times to ensure statistically valid results and an Effective Perceived Noise Level (EPNdB) is recorded for each procedure. A number of conditions, such as take off mass, speed, height and rotor speed, are placed on each procedure to ensure repeatability and reliability of the results. In addition, corrections can be made to the EPNdB levels according to variability in height, meteorological conditions such as temperature and humidity and ground speed of the helicopter [41].

4.7.3. Light helicopters require only one flight configuration for noise certification, take-off flight path with maximum power, to be recorded. The noise level is measured in SEL (dB). Light helicopters must be quieter than heavier ones.[42]

4.7.4. A window of acceptable meteorological conditions and site qualities for microphone placement is specified in appendix 4 of the IACO Annex 16.

4.7.5. For each flight, the EPNdB is averaged across the three microphones. Repeated flights are carried out for each procedure until the 90% confidence limits for EPNdB of ± 1.5 dB are achieved [41].

4.7.6. In order to pass certification the EPNdB values must fall below a reference limit for each procedure. Relaxations to these limits are made (due to the lack of accurate noise prediction tools at the design stage) where helicopters may exceed the EPNL dB limits by 3dB over one procedure, or by 4dB over two procedures, as long these deficits are offset across the other procedures [41].

4.7.7. The EPNL (Effective Perceived Noise Level) and the SEL (Sound Exposure Level) metrics utilise the upper 10dB of a flyover time record. However, the sound of a helicopter at distance, although outside this upper 10dB region, can still cause annoyance, especially where high levels of impulse noise are present [2].

4.7.8. Helicopter noise certification is concerned only within specific flight operations and often these do not relate to urban helicopter operations. An example of this is the ground-running phase, which is ignored in the certification procedure. However, it should be noted that the purpose of noise certification is to encourage the design of quieter aircraft. In the case of helicopters, the design choices required to satisfy certification requirements would serve to limit noise in all operating modes.

4.8. Rules and regulations in Australia

4.8.1. In Australia, the Civil Aviation Safety Authority (CASA) was established in 1995 to conduct the safety regulation of civil air operations in Australia, and the operation of Australian aircraft overseas. The Civil Aviation Regulations 1988 and the Civil Aviation Safety Regulations 1998, made under authority of the Civil Aviation Act, provide for general regulatory controls for the safety of air navigation [43].

4.8.2. CASA functions as a safety regulator and Airservices Australia as a service provider. Airservices Australia is a government-owned corporation providing air traffic control, air navigation support and rescue and fire fighting services [44]. Airservices Australia are described by the CASA as providing a "safe and environmentally sound air traffic control management and related airside services to the aviation industry" [45].

4.8.3. CASA summarises the rules and regulations regarding helicopters operating under visual flight rules in the document, 'Visual flight rules guide - Version 2 - July 2007' [46].

4.8.4. A Helicopter must not fly over any city, town or populous area, at a height lower than 1000 ft, or any other area at a height lower than 500 ft. The heights specified are the heights above the highest point of the terrain, and any object on it, within a radius of ≈1000 ft (300 m) from a point on the terrain vertically below the aircraft.

4.8.5. These rules do not apply when the height must be lower because of metrological conditions, if the pilot has a permit for low level operations, if the pilot is engaged in low flying training authorised by CASA, if the aircraft is taking off or landing, if the pilot is engaged in a search/rescue, or during police operations.

4.9. Rules and regulations in Europe

4.9.1. The Joint Aviation Authorities (JAA) is an associated body of the European Civil Aviation Conference (ECAC) representing the civil aviation regulatory authorities of a number of European States who have agreed to co-operate in developing and implementing common safety regulatory standards and

procedures. This co-operation is intended to provide high and consistent standards of safety and a "level playing field" for competition in Europe. Much emphasis is also placed on harmonising the JAA regulations with those of the United States' FAA [47].

4.9.2. The European Aviation Safety Agency (EASA) was set up to promote the highest common standards of safety and environmental protection in civil aviation. It is intended to be the centrepiece of a new cost-efficient regulatory system in Europe and a reliable partner for equivalent authorities throughout the world. As EASA develops the aviation regulatory environment, it will change some of the existing CAA processes and procedures [48].

4.9.3. EASA became operational on 28 September 2003 and it will be fully functional in 2008. It is an independent legislative body under European law, accountable to the Member States and the European Union institutions. EASA itself is not an International Civil Aviation Organization (ICAO) signatory because it does not constitute a State; however, it works closely with ICAO and the Federal Aviation Administration (FAA) with the aim of harmonising standards and promoting best aviation practice worldwide [49].

4.9.4. The creation of EASA has had a significant impact upon UK Registered aircraft. EASA has assumed responsibility for the type-certification and continued airworthiness of a large number of UK registered aircraft. [49]

4.9.5. During the next few years, it is intended that the agency will extend its responsibility to aircraft operations, crew licensing and the certification of non-Member State airlines [49]. The UK is represented on the EASA management board by Mr. Michael Smethers (Vice Chairman Director, European & International Strategy Civil Aviation Authority) and Mrs. Natasha Coates (Head of the Aviation Safety Team, International Aviation & Safety Division, Aviation Directorate, Department for Transport) (http://easa.europa.eu/home/g_mng_brd_main.html).

4.10. Rules and regulations in the USA

4.10.1. The Federal Aviation Administration (FAA) regulates operations in United States airspace. The regulations are called the Federal Aviation Regulations (FAR) and are part of the Code of Federal Regulations (CFR – title 14).

4.10.2. Federal Aviation Regulation section 91.119 [50] states that aircraft must maintain a minimum distance of 1,000 ft above the highest obstacle and a horizontal radius of at least 2,000 ft from another aircraft. In other than congested areas, aircraft are required to maintain an altitude of at least 500 feet above the surface over open water or sparsely populated areas. Over open water or sparsely populated areas, aircraft may operate at less than 500 feet above the surface provided that they do not fly closer than 500 feet to any person, vessel, vehicle, or structure. Helicopters may be operated at less than these minimum altitudes provided that they are conducted without hazard to persons or property on the surface. [50]

4.11. Summary of Chapter 4

4.11.1. 4.11.1. The CAA provides a focal point for receiving and responding to aircraft-related environmental complaints from the general public. However, the CAA does not have the legal power to prevent aviation activity on solely environmental grounds, except when considering changes to the structure of controlled airspace. An independent review is considering greater powers for the CAA over environmental matters.

4.11.2. There are only three licensed heliports in the UK, although helicopters can land at most airfields. Temporary landing sites can be used for up to 28 days in a year. A residential planning application close to an operating heliport, when evaluated in accordance with PPG24, should not rely solely on Leq and should consider the intermittent nature of helicopter operations.

4.11.3. Helicopter noise certification is not directed at urban operations. BHAB codes of practice aim to increase the helicopter pilots and operators awareness of environmental noise issues. Although pilots are aware of noise issues, factors such as safety are considered to be more important.

5. Subjective responses to helicopter noise

This section summarises a literature review of the subjective responses to helicopter noise. Principal references include the 2004 FAA report to the US Congress, publications by Leverton and Pike, and the WHO Guidelines for Community Noise. This section addresses the adverse effects of helicopter noise including sleep disturbance, health and annoyance, before moving on to non-acoustic factors including 'virtual noise' and building vibration. Much of this review refers to the effects of fixed wing and general aviation noise on the individual. Throughout comparisons are drawn between the effects of helicopter noise with the effects of fixed wing aircraft noise.

5.1. Social effects

5.1.1. The 2004 FAA report to US Congress entitled, 'Non-military Helicopter Urban Noise Study' [4] (henceforth referred to as the FAA report), contains a comprehensive literature review on the effects of noise on the individual. The 2004 FAA report was itself in part based upon the US military report 'Community response to helicopter noise' [51]. This review has been used together with other sources to summarise the effects that helicopter noise has on the individual.

5.1.2. Studies have shown that environmental noise, including aircraft and traffic noise can adversely affect classroom learning [52-58]. It has been shown that low achieving students were the most adversely affected. In addition; students with hearing impairments, students with English as a second language and music students may be particularly adversely affected [59]. The WHO (World Health Organisation) recommends that in schools, a maximum equivalent indoor level of background noise not exceeding 35dBA. This is so that the average voice level (50dBA) is at least 15dBA above the background level [59]. The FAA report states that nearly all of the studies relate to the classroom environment and that "at the present time, little can be said of environmental noise effects on communications and performance except as it relates to the classroom setting".

5.1.3. Studies carried out at RAF Shawbury [60] which has around 114,000 helicopter movements per year indicated no clear correlation between traditional

acoustic parameters and soundscape perception and acceptance. There did, however, appear to be a correlation between acceptance and the value/meaning attributed to the noise/event. Sixsmith [61] has suggested that the use of the term of 'annoyance' might be replaced with a number of other terms. This suggestion stems from her work with 'work-related stress', a phenomenon that is now described in terms of 6 different factors; demands, control, support, relationships, roles and change [62].

5.1.4. Sensitivity to low frequency noise. A number of studies over the past 30 years have suggested that a subsection of the population is more sensitive to low frequency noise than the majority. Patterson et al [63] performed tests with different frequency weightings on aircraft noise, comparing the dB level with annoyance. It was reported that most of the ratings correlated best with A-weighting. However, 11 out of 25 subjects also had good correlation with C-weighting, and of the 11, 3 exhibited better correlation with C-weighting. For this reason, it was concluded that A-weighting might not be the ideal weighting. ANSI S12.9 Part 4 provides a supplemental measure to A-weighting for assessing industrial noise sources with strong low-frequency content. Schomer suggested the use of equal loudness contours as more detailed frequency weighting curves for different amplitudes and showed a 2 dB difference between fixed-wing and rotary wing aircraft derived directly from these known functions of human hearing [4]. In addition, it is found that increasing the loudness of a modulating sound by 2-5dB produces the same change in perceived loudness as if it were a change in loudness of 10dB[64]. This could be significant for helicopters indicating one reason why they are rated differently to fixed wing craft. Likewise, Defra-funded research on the assessment of LFN complaints concluded that 5dB was an appropriate penalty for fluctuating low frequency sounds [65].

5.2. Health effects

5.2.1. The Department for Transport in 1992 commissioned a report entitled 'Report of a Field Study of Aircraft Noise and Sleep Disturbance'[66]. This study measured the sleep disturbance of people

in their homes near Heathrow, Gatwick, Stansted and Manchester airports. At outdoor event levels below 90 dBA SEL (80 dBA Lmax), average sleep disturbance rates are unlikely to be affected by aircraft noise. At higher levels, and most of the events upon which these conclusions are based were in the range 90 to 100 dBA SEL (80 to 95 dBA Lmax), the chance of the average person being awakened is about 1 in 75. The report concluded that high aircraft noise levels could awaken people but that the likelihood of the average person having his or her sleep noticeably disturbed due to an individual aircraft noise event was relatively low. However, a small minority of people were more sensitive. Additionally, it was unclear amongst those who suffer disturbance due to noise, whether a single loud noise event or the accumulation of smaller noise events causes more disturbance. It should be noted however that study sites were selected on the basis of arrival and departure routes of the airports and thus fixed winged aircraft would have been the predominate activity.

5.2.2. In 1998, a further study was commissioned by the Department for Transport[67] to review existing research in the UK and abroad and to conduct a trial to assess methodology and analytical techniques and to determine whether to proceed to a full-scale study of either sleep prevention or total sleep loss. This involved a methodological trial to assess whether 'aircraft noise causes harmful loss of sleep throughout the night' and 'the effect of sleep delay and disturbance at the beginning and end of the night'. A social survey was also carried out to help explore the marked difference between objectively measured and publicly perceived disturbance due to night-time aircraft noise. However again it is worth noting that fixed wing aircraft would have been predominate.

5.2.3. The Government announced on 8 May 2001 that a new full-scale objective sleep disturbance study would be unlikely to add significantly to existing knowledge; it is to concentrate instead on further research into subjective responses to aircraft during both day and night.

5.2.4. Laboratory experiments [68] have shown sleep disturbance at relatively low noise levels but field tests results have shown people are much less susceptible to being disturbed. For example, field tests show 1% of participants were awakened at 60dB (A-weighted sound exposure level) while in laboratory tests at 60dB about 20% of people were disturbed. This is presumed to be due to the unfamiliar conditions in the laboratory tests. The US Federal Interagency Committee on Aviation Noise (FICAN) recommends using a dose-response curve for predicted awakening based upon the field data. In essence, the dose-response curve would follow the "maximum percentage of the exposed population expected to be behaviourally awakened" related to SEL. The FAA agrees with this recommendation.

5.2.5. The WHO[59] states that long term exposure to noise levels exceeding 65-70dB (24 hr Leq) are known to be associated with causing cardiovascular problems. Passchier-Vermeer[69], commenting on results from studies carried out in the Netherlands, states that the observation threshold for hypertension is estimated to correspond to an Ldn value of 70 dB(A) for environmental noise exposure. The FAA report states that "Helicopters rarely produce 24-hour equivalent levels that exceed 70 dB. In fact, such worst case, high noise levels only occur near very busy military airfields operating heavy lift helicopters and frequent flights. Thus, noise-induced hearing impairment due to non-military helicopters operations in urban environments is an unlikely condition".

5.2.6. Recently published work by the HYENA group[5] (Hypertension and Exposure to Noise near Airports) indicated a statistically significant excess risk of hypertension related to long term exposure to night-time aircraft noise. For every 10dB increase in (night-time) noise level, the risk of hypertension is increased by about 14%, with this trend seen starting at low levels. The daytime results were not statistically significant.

5.3. Community attitudes

5.3.1. Community attitude toward operations has an important effect on the community annoyance. Social surveys carried out by the CAA in 1982 and 1992 [112] [113] found that helicopters in the London area were up to 15dB(A) more annoying at the 10% and 20% Very Much Annoyed Level than fixed-wing aircraft. By contrast, results showed that helicopters operated in Aberdeen, servicing the North Sea oil industry, generated similar annoyance for a similar sound level as their fixed wing counterparts. This is attributed to the obvious economic benefit to community surrounding the Aberdeen helicopter service as opposed to London, where helicopters are perceived to have no economic benefit to the residents. This indicates a strong non-acoustic factor in the community annoyance rating.

5.3.2. The Fields study [70] highlighted the following five attitudes as most important .

- 1) Noise prevention beliefs.
- 2) Fear of danger from noise source.
- 3) Beliefs about the importance of the noise source.
- 4) Annoyance with non-noise impacts from the noise sources.
- 5) General noise sensitivity.

5.3.3. The US Environmental Protection Agency (EPA) in 1974 [71] suggested that the measured noise level could be adjusted downward by 5dB when the noise generating party maintains good relations with the community. On the other hand, it is deemed that many helicopter flights are non-essential and it is sometimes suggested that negative attitudes come from the opinion that the helicopter is just the rich man's toy.

5.3.4. Leverton [3] comments that "the public acceptance of helicopters is not wholly reflected by either conventional community rating procedures or the noise certification requirements". This questions the view of many national authorities that a reduction in the objective sound level that helicopters produce will make helicopters more acceptable to community.

5.3.5. Most noise rating procedures utilise the A-weighted sound pressure level integrated over a relatively long period. However, this may not be appropriate when there are a small number of events, as discussed by Leverton: [3] "the effectiveness of methods based on long term averaging is questionable in those cases where the duration of the event is very much shorter than the evaluation period and the number of events in that period is such that noise levels are subject to large variations."

5.3.6. Fields and Powell [72] studied the reaction to low numbers of helicopter noise events. There was a strong relationship between average Leq and average annoyance over the range of 1 to 32 flights in 9 hours. The study found annoyance was flat in relation to Leq up to 47dB, then a linear relationship of increasing annoyance up to 59dB. However, it was found that the number of noise events had little effect on annoyance although close statistical analysis revealed the possibility that the event number has no effect on the relationship could not be rejected (with greater than 95% confidence). Additionally, the study compared helicopters with an impulsive sound character (UH-1H "Huey") and one with a non-impulsive sound character (UH-60A "Black-hawk") and found "there is not an important difference between reactions to impulsive and non-impulsive types of helicopters". The FAA and the US army reports comment that no one has carried out a study to determine a similar Leq-annoyance relationship for night-time but that the traditional 10dB night-time penalty, used in the determination of DNL, is consistent with community attitudinal data [73].

5.3.7. It was widely believed in the 1970s that helicopter noise was more annoying than fixed wing noise and as a result the U.S. Department of Defense policy was that a 7dB penalty should be applied "to meter readings obtained where Blade-Slap was present unless meters are developed which more accurately reflect true conditions" [74]. The need for a blade slap penalty was based on results from laboratory tests carried out by Leverton [75]. These tests, carried out in a simulated living room, showed that the presence of blade-slap increased

annoyance by the equivalent of between 4-8dBA. The US army report recognised a number of other researchers who also identified the need for a 'blade-slap correction factor' [76-79].

5.3.8. Other researchers have offered alternative indices for measuring community annoyance. Examples include the 'roughness' of the sound quality, the rate of the impulses, or the energy in the 50-200Hz band [4].

5.3.9. The FAA and the US army reports comment that subsequent field tests have failed to support the addition of the blade-slap penalty. NASA reported that "A careful analysis of the evidence for and against each factor reveals that, for the present state of scientific knowledge, none of these factors should be regarded as the basis for a significant impulse correction." [80] Passchier-Vermeer commented "tests have shown on average only minor differences in annoyance rating of more or less impulsive helicopter noise with the same noise levels" [81]. The FAA comments that: "There is general agreement among a wide range of experts that adding a penalty to the A-weighted SEL to account for the annoyance of Blade-Slap is not justified." [4]. Despite this, others dispute the efficacy of EPNL and other metrics to rate subjective response to helicopter noise[82]. Although the ICAO report to CAN7 (1983) concluded that EPNL is satisfactory, it also states that "pending better knowledge on this subject, operational procedures should be investigated in order to reduce the number of occasions where 'blade slap' or more appropriately, impulsive noise appears". It should be noted that the positive conclusion about EPNL was, at least in part, because nothing better could be found at the time [82].

5.3.10. Despite objective evidence that helicopters are no more annoying than fixed wing craft, public surveys indicate a more negative reaction to helicopter noise. Leverton et al [3] holds the view that specific properties of the helicopter sound are not accounted for by conventional rating procedures and it is these properties that are among the major sources of annoyance for the community. Specifically, rating procedures do not account for noise from the main rotor

blade/tip vortex interaction (BVI), main rotor thickness noise and impulsive noise resulting from shock waves commonly referred to as high speed impulsive noise (HSI), main rotor wake/tail rotor interaction (TRI), and tail rotor noise (TR). NASA research indicates that the addition of a 'correction factor' for impulsive sounds does not improve the human response - parameter correlation. However, these tonal and impulse components have a profound effect on the human response even at levels 15 – 25 dB below the maximum level. The EPNL or SEL based parameters used in aircraft certification, including helicopters, are calculated using only the maximum 10dB dynamic range, and therefore these effects are not accounted for.

5.4. Non-acoustic factors

5.4.1. Leverton [3] describes the public acceptance of helicopter noise as a function of two factors: acoustic noise and non-acoustic factors referred to as 'virtual noise'. The virtual noise element is related to non-acoustic factors such as fears for safety, or poor community relations with operators. Virtual noise is not related to the absolute level of acoustic noise although is triggered by it. It can also be triggered by visual cues. Annoyance is quantified in terms of objective acoustic parameters and therefore the virtual noise is generally treated in the same manner as the acoustic noise even though the virtual component is unrelated to absolute acoustic levels. This means that when problems stem from the virtual noise component, any reduction of the noise level will be ineffectual.

5.4.2. It can be difficult to separate virtual and acoustic noise, as these factors are highly interrelated. Research referred to by Leverton [3] and carried out at ISVR [83] attempted to classify complaints and quantify the 'virtual noise' effect in terms of an equivalent A-weighted correction factor. Although the research was based at general aviation airfields where mainly light fixed wing craft operated, results have suggested similar trends for helicopters.

5.4.3. These results have not been shown to translate directly to helicopter operations, although results from helicopter operations at one base indicated a similar result. In fact, the negative reaction to helicopters may be even higher especially in reaction to leisure flying. The virtual noise factor can be very low in some cases. As mentioned previously, in Aberdeen, helicopter operations servicing the North Sea oil industry are seen as beneficial and are more acceptable. Similarly, it may be that helicopters following precise routes are more acceptable, and therefore the virtual noise factor is reduced. An example of this is the Helijet scheduled passenger service between Victoria and Vancouver. ICAO work has suggested that fear of crashes is the most significant factor in addition to low flying, sudden changes in the noise signature and previous experience of crashes all contributing the most to the negative reaction.

Negative reaction to leisure flying	+5dB(A)
Poor community/airfield relations	+10dB(A)
Fear of crashes	+10dB(A)
Nobody acts on complaints	+20dB(A)
Aircraft are flying too low	+20dB(A)

Table 4: 'Virtual noise' effect in terms of an equivalent A-weighted correction factor

5.4.4. The FAA report refers to a number of tests carried out between 1985[84] and 1991[85] that compared the lack of, or presence of, audible noise induced rattle in dwellings. It was found that the presence of a rattle could increase the annoyance by an equivalent level of between 10 and 20dB.

5.4.5. The FAA report describes in-situ tests carried out by Schomer and Wagner [86] at residents' properties using an external sensor to register events for the same A-weighted sound exposure level (ASEL). These showed that helicopter sound was no more annoying than the fixed wing noise. However, the rate of response in terms of noticeability of the helicopter noise events was higher than that for fixed wing noise events. Helicopters, with their distinctive sound character, are more noticeable than other sounds for the same ASEL.

5.4.6. At the recent IoA (Institute of Acoustics) meeting at Salford, Pike [2] commented that there is a need for psychoacoustics experts to work with industry to address the unique subjective character of helicopter noise. Furthermore, workshops should be held to address the negative perception of helicopter and the 'virtual noise' factor.

5.5. Comparison with Light aircraft/microlights

5.5.1. In studies carried out at RAF bases investigating the management of Light aircraft and microlight noise at military airfields [9, 87], a number of similar problems as described regarding helicopter noise were found.

- 1) Correlation between nuisance and noise level is poor. It is clear that more relevant descriptor metrics are required for low volume or irregular microlight and light aircraft operations.
- 2) It is likely that actual noise level is a secondary issue and that physical intrusion and other non-acoustical factors are more significant in determining nuisance.

5.5.2. Background noise level is likely to be a factor as it (generally) relates to the 'rurality' of complainants locations. Civil aviation is always described in absolute terms with no reference to the background/ ambient level.

5.5.3. Alongside helicopters, light aircraft are precluded from prosecution under noise nuisance.

5.5.4. Both reports state that consultation with the public will help to engage people and breed more understanding for the operations.

5.6. Summary of Chapter 5

5.6.1. Reaction to helicopter noise is determined by acoustic and non-acoustic 'virtual' noise. Non-acoustic factors are of equal or greater importance but are triggered by impulsive noise generated by the basic rotor mechanism. This means that addressing acoustic noise limits is unlikely to significantly improve public acceptance of helicopter noise.

5.6.2. Subjective responses are known to be influenced by factors other than noise including flight safety, privacy, soundscape, locus of control and mental health. Perceived effect on house price has also been shown to be a significant factor. Highest annoyance has been correlated with uncommon or exceptional helicopter events.

5.6.3. Complaints have been found to be more likely if the resident has a negative attitude towards the helicopter operator. Additionally, the likelihood of a member of the public making a complaint appears not to be influenced by age, length of residence, having children or not, or health.

5.6.4. Social surveys indicate that helicopters are 10 to 15 dBA more annoying than fixed-wing aircraft for the same or lower measured sound level. The term annoyance does not fully describe the subjective response to helicopter noise. The following classifications, amongst others, are also important; intrusion, distress, startle, disturbance, locus of control.

5.6.5. Studies attempting to relate dose-response with annoyance due to helicopter operations have produced poor correlation and have been broadly criticised. There is no generally accepted straightforward relationship between objective noise and subjective annoyance. No good correlation with complaints has been found with LAeq, LCeq, LAmx, L10 and LAmx-L90.

5.6.6. Studies addressing the noise from light aircraft and microlights reveal similar issues; that noise level may be a secondary issue and different indices may be required for low volume operations.

6. Management of Environmental Noise from Helicopters

This section considers the effectiveness of current procedures for dealing with helicopter noise in the UK. Existing procedures for handling complaints are detailed and the roles, responsibilities and powers of the various authorities and regulating organisations summarised. Comparisons are drawn with other European countries, the USA and Australia. Finally, noise prediction and modelling are discussed with particular relation to noise mapping and EU Noise Directive (Directive 2002/49/EC). Options for improvement are identified together with recommendations on how these could be implemented.

6.1. Existing procedures for handling noise complaints from helicopters

6.1.1. The Civil Aviation Authority (CAA) is a focal point for receiving environmental complaints about aircraft. When a complaint is received, the location, aircraft type and identity (registration/features) are recorded and the airspace structure in that area is identified. The legislative background to noise, and the ANO with specifics to the location, are explained to the complainant. However, the CAA has no legal power to prevent aviation on solely environmental noise grounds [6].

6.1.2. The outcome of a complaint to the CAA will either be:

- 1) a referral to ARED (Aviation Regulation Enforcement Department) in the event of a breach of the ANO, or
- 2) advise contact of local planning authority in the case of a change of land use or to advise contact the aircraft operator directly.

6.1.3. The Directorate of Airspace Policy Environmental Information Sheet - Number 1 entitled 'Aircraft Noise'[88], comments that the CAA is tasked with ensuring that procedures at airports meet required standards of safety but the operators are responsible for the environmental impact of their aircraft operations. The CAA is expected to, "strike a balance between the needs of the airport/aircraft operators and the needs of the local community". As a result, the CAA encourages noise complaints to be made directly to the airport operator.

6.1.4. Problems related to noise generated on the ground at aerodromes, other than in association with the normal operation of aircraft, should be referred to the Local Authority. However, local authorities have a statutory bar on action against aviation noise sources under the Environmental (EPA) noise legislation.

6.1.5. MOD complaints are dealt with centrally or through the base's community liaison officer
<http://www.mod.uk/DefenceInternet/AboutDefence/WhatWeDo/AirSafetyandAviation/LowFlying/HowDoIComplainAboutMilitaryLowFlyingActivity.htm>,

6.1.6. The London Heliport at Battersea has established a complaints telephone line for registering environmental noise complaints (0207 228 0181). Complaints are reported at the consultative group meetings [16]. The heliport is not responsible for all traffic over London and currently there is no formal complaints procedure in place for helicopters flying within the London Control Zone that are not operating at the London Heliport. This is being addressed by the London Assembly and Defra but in the interim, the Civil Aviation Authority is tasked to respond to complaints [89].

6.2. Means of redress for any perceived disturbance caused

6.2.1. The Department for Transport is involved directly with measures to ameliorate aircraft noise at Heathrow, Gatwick and Stansted.. Elsewhere "the Department expects civil aerodrome and aircraft operators to achieve a reasonable balance between their legitimate needs and those of the local community" [26].

6.2.2. Aerodrome operators may publish noise abatement procedures to be followed on a voluntary basis. For example, it may be requested that pilots avoid overflying a certain village. However, these procedures are voluntary and it may not always be possible to design such procedures due to aircraft performance and operational constraints [90].

6.2.3. Noise preferential routes (NPR) may be employed at major airports although these are essentially designed with fixed wing aircraft in mind. These are designed so that immediately after take off aircraft will avoid the most densely populated

areas. Typically, aircraft should not deviate from these routes until above 3,000 ft. Details of specific NPRs are available from the airports. In the recent 'Civil Aviation Act (2006)' airports are now able to apply a charging scheme to promote the use of cleaner, quieter aircraft [90].

6.2.4. At Birmingham International Airport, after receiving a number of complaints about police operations via their consultative committee in 2006, the airport consulted with the police operators, the air traffic control and the environmental department at the airport to implement an 'avoid' region to minimise flights close to residences.

6.2.5. At RAF Shawbury, in response to an increase in the number of complaints a point of contact has been published. Observations, measurements, acoustic studies and trend analysis have been carried out and detailed records are kept. Some noise management is achieved by active management of flying by rotating routes, expanding the user area, and briefing all new staff and students to make them aware of environmental issues. Wing Commander Tim Owens commented [91] that a fast response to complaints is important in keeping complainants from becoming a repeat complainer. Individual invitations to visit the base and follow up contact are also important in order to inform and to ensure the public are aware the RAF is doing the utmost to address environmental issues [91].

6.2.6. At the London Heliport, a consultative committee has been set up. Wandsworth council commented[92] that this shows residents that their concerns are being taken seriously, increases awareness within the planning department, and lets the operator be confident that there is no hidden agenda. Complaints are largely generated from living standard expectations and a perception that helicopter pilots demonstrate inconsiderate behaviour. It has been conjectured that change of land use from industrial to residential usage is the root of the problem. The council commented that enabling dialogue between residents, councils and the heliport operator has helped to create some understanding and acceptance by the public. The dialogue should be

extended to include developers so that homes are created with sufficient sound insulation. At the recent IoA meeting, Steve Mayner commented that "noise mapping may be unlikely to reduce annoyance due to lack of technical understanding by the public, but that it may be useful for the planners" [93].

6.2.7. The Directorate of Safety and Claims (DS&C) and the Environment and Safety Division administrate the Noise Insulation Grant Scheme (NIGS) on behalf of the MOD. NIGS is a non-statutory compensation scheme that provides direct assistance to members of the public who reside in the vicinity of military airfields and who may experience disturbance from the activities of the aircraft. NIGS is broadly comparable with the noise insulation schemes, recommended by the Department of Transport, in place at the designated civil airports of Heathrow and Gatwick. The policy of the NIGS scheme is revisited every five years to ensure that it is still comparable with the UK civil aviation practices [94].

6.2.8. In January 2000 a study was completed [60] which examined the relationship between noise levels and patterns of complaints caused by RAF Shawbury's helicopter activity. The report concluded that no residential properties were eligible for assistance under the current criteria for NIGS. This triggered a review of NIGS policy and the scheme was suspended pending the outcome of the review. Part of the review was the MOD Aircraft Environmental Noise (AEN). Results from AEN were published in 2004, its recommendations were wide ranging and carried implications across the whole of MOD. Consultation resulting from AEN is still ongoing. One of the outcomes of AEN was that the NIGS scheme should be restarted as soon as possible however a funding application for the scheme in 2005/2006 was rejected "*due to other funding priorities of the Defence Budget*" [94]. In April 2005 NIGS was formally and indefinitely suspended (including carrying out of reviews and surveys). However "*this suspension would be kept under review and if circumstances allowed the reintroduction of NIGS in the future, then this would be examined at that time*"[94].

6.2.9. The Noise Insulation Grant Scheme was based on nighttime operations exceeding 20 movements with L_{Amax} of more than 82dB and two daytime L_{Aeq,16hr} levels of 70dB and 83dB. For the lower level of 70dB double glazing grants were offered and for the higher level compulsory purchase of property applied. The scheme was reviewed by Ralph Weston in 1991 and it was concluded that the nighttime L_{Amax} level of 82dB was inappropriate for helicopters. Instead a 10dB penalty was suggested to represent public disturbance due to helicopter operations and subsequently a 72dB nighttime maximum was proposed. Helicopters also pose a problem for noise insulation because double glazing is less effective for the low frequency content of helicopter noise[95].

6.2.10. BAA has established non-statutory noise insulation schemes, as the operators of regional airports have done. The provisions vary but BAA's latest scheme at Stansted, for example, offers an insulation package to residences within the 66dB L_{Aeq} (16h) (with a separate night noise criterion) and relocation assistance to properties falling within the 69dB L_{Aeq} (16h) contour [96]. The 2003 Air Transport White Paper states (para 3.24) [114] that insulation should be provided, in the context of airport development, where properties are exposed to noise levels of 63dB L_{Aeq} or more and subject to an increase of 3dB or more.

6.3. Roles, responsibilities and powers of the various authorities and regulating organisations.

6.3.1. The Department for Transport will respond on matters of overall policy.

6.3.2. The Civil Aviation Authority (CAA) has responsibility on regulation, airspace design and environmental complaints. However, the CAA will only advise on the regulations; they cannot act unless there is a clear breach in the rules of the air.

6.3.3. The Ministry of Defence has responsibility for information and complaints related to military aircraft operations.

6.3.4. National Air Traffic Services has responsibility on airspace operations.

6.3.5. Airport operators deal with complaints where, for example, a take-off appears not to follow established procedures. This is because they have immediate access to data relating to that take-off.

6.3.6. Local authorities have the responsibility to deal with complaints arising from the operation of machinery or other noise not generated directly by aircraft

6.4. The effectiveness of dealing with helicopter noise in the UK using current methods

6.4.1. At RAF Shawbury complaints are dealt with by maintaining good relations with the community through a swift response to all complaints, following up complaints with invitations to visit the base, acoustic studies and operational changes. It appears that the perceived value of the operations has been reinforced in the public mind and complaints have not risen in line with operations [91].

6.4.2. At the recent seminar Wandsworth Council reported [93] that recent efforts encouraging dialogue between residents, councils and the heliport operator have helped to improve understanding and acceptance by the public. However, it was suggested that this might be a 'honeymoon period'. The dialogue could be extended to include developers so that homes are created with sufficient sound insulation. Noise mapping is thought to be unlikely to reduce annoyance due to lack of technical understanding by the public but it may be useful for the planners.

6.4.3. The London Heliport operator stated that the telephone complaints line, established before working with Wandsworth Council, has significantly helped relations between the heliport and the public. The helpline is continually being refined since a more informed public realises that it is not always the heliport that is responsible for disturbance and that through traffic may be the cause of the noise nuisance [16].

6.5. Comparisons with other European countries

6.5.1. The Advisory Council for Aeronautics Research in Europe defines and implements the Strategic Research Agenda (SRA). There are two significant projects that address noise from helicopters; FRIENDCOPTER and the "Clean Sky" JTI [97].

6.5.2. FRIENDCOPTER is currently underway and is an Integrated Project of the European 6th Framework Program: "Integration of Technologies in Support of a Passenger and Environmentally Friendly Helicopter". This project was started on 1st March 2004 and is due for completion by 31st August 2008. The research is being carried out by a consortium of 34 European partners including helicopter manufacturers, research establishments, and universities [98].

6.5.3. The research goals of FRIENDCOPTER are to achieve a reduction of:

- 1) acoustic footprint area by 30-50%,
- 2) fuel consumption by 6 % in high speed flight,
- 3) cabin vibrations below 0.05 g and
- 4) cabin noise levels below 75dBA.

6.5.4. These research goals of FRIENDCOPTER are to be achieved by:

- 1) low noise flight procedures,
- 2) quiet engine in/outlets,
- 3) interior noise reduction and
- 4) distributed blade actuation.

6.5.5. The "Clean Sky" Joint Technology Initiative (JTI) program is an industry driven 7-year research plan for a greener generation of European Air Transport that will radically improve impact on the environment while strengthening and securing European aeronautics industry's competitiveness [99].

6.5.6. The purpose of The "Clean Sky" JTI program is to demonstrate and validate the technological breakthroughs that are necessary to reach the environmental goals set by the Advisory Council for Aeronautics Research in Europe (ACARE: the European Technology Platform for Aeronautics & Air Transport).

6.5.7. ACARE goals to be obtained in 2020 through the Technology Domains developed in the Clean Sky JTI program are as follows:

- 1) 50% reduction of external noise.
- 2) 50% reduction of CO2 emissions through drastic reduction of fuel consumption.
- 3) 80% reduction of NOx emissions.
- 4) A green design, manufacturing, maintenance and disposal product life cycle.

6.5.8. The Clean Sky JTI program is articulated around 6 Integrated Technology Demonstrators (ITDs). One of these Demonstrators is called 'Green Rotorcraft' which is intended to deliver innovative rotor blades and engine installation for noise reduction, lower airframe drag, integration of diesel engine technology and advanced electrical systems for elimination of noxious hydraulic fluids and fuel consumption reduction [100].

6.5.9. The target for the Green Rotorcraft ITD is a reduction in the certification noise levels of 10EPNdB [2]. A number of major European aerospace manufacturers; AgustaWestland Airbus SAS, Dassault Aviation, Eurocopter SAS, Liebherr-Aerospace Lindenberg GmbH, Rolls-Royce plc, Safran and Thales are involved in the Clean Sky JTI [101] and additional partners will be selected via open Calls for Proposals [102].

6.6. Comparisons with Australia

6.6.1. Airservices Australia publishes a guide entitled 'Environmental Principles and Procedures for Minimising the Impact of Aircraft Noise'. It points out that in all cases aviation safety, including system safety through simplified operating arrangements, will be given priority over noise abatement considerations [46].

6.6.2. The guide is written in a hierarchical manner with the most preferred procedures for helicopter operations given first. They are as follows:

- 1) No overflight of residential areas.
- 2) No overflight of residential areas below 1,500 ft AGL.
- 3) Minimisation of incidence of helicopters flying below 1,500ft AGL.
- 4) Minimisation of noise impact on

residential areas by helicopters below 1,500 ft AGL.

- 5) Minimisation of noise impact on residential areas by hovering/circling helicopters.
- 6) Implement fly neighbourly procedures.

6.6.3. However, assuming safety conditions have been satisfied, the sole test for moving to a lower level standard is that the higher standard is "not operationally practicable". If lower rather than higher standards are chosen, then well-documented reasons for the decision are required. The noise standard chosen should be achievable for at least 90% of movements.

6.6.4. In Australia, there are several avenues for people with aircraft noise issues to register a complaint. These include the Airservices Australia Noise Enquiry Unit (NEU), the relevant airport, consultative committees and local and Federal politicians. Even if the complainant does not contact the NEU direct, the NEU will generally be contacted by the receiver of the complaint to help provide input for a response. More often than not, helicopter complaints relate to helicopter operations near airports, so there is a tendency for new complainants to make their initial complaint to the airport owner/operator. Other people, particularly those who also have issues with fixed wing aircraft noise, are familiar with the complaints reporting service provided by Airservices and will contact the NEU direct. [103]

6.6.5. Some airports are very proactive in resolving problems; others simply refer complaints on to the NEU. Helicopter operators are often unaware they are causing a problem and on receiving a complaint will attempt to alter operations to reduce the problem. Other airports, however, will simply state that they are carrying out a legal operation and will continue to do so without modification. "Fly Neighbourly" agreements are sometimes successful, but these are purely voluntary and have no legal standing [103].

6.6.6. At the end of each month, a statistical report is generated and provided to stakeholders. Main problem areas are around airports and hospitals [103].

6.6.7. Provided that the rules of the air are observed, no penalties apply. Wherever possible, attempts are made to minimise effects of aircraft noise by consultation [103].

6.7. Comparisons with the USA

6.7.1. The Federal Aviation Administration (FAA) has procedures to respond to the public about aircraft noise questions or complaints within the United States. The FAA website comments that "Most airports have an office that responds to airport noise issues, or the airport manager will respond to noise complaints. You can also contact your local FAA Airports District Office (ADO) for assistance" [104].

6.7.2. In the US, urban encroachment near military bases can compromise operations at the base. Litigation is possible [105] and public pressure can lead to closures, transference or modification of activities, curtailing of operations. In the US noise contour prediction methods, such as the Integrated Noise Model, are used to reduce the environmental impact of military activities.

6.7.3. In the US, the Helicopter Association International (HAI) [106] heavily promotes the Fly neighbourly program. This program is effective in some areas in the US at reducing the noise impact. [107] The Fly Neighbourly Program consists of a guide [108] and a pilot training CD. The Program addresses noise abatement and public acceptance objectives with programs in the following areas:

- 1) Pilot and operator awareness
- 2) Pilot training and indoctrination
- 3) Flight operations planning
- 4) Public acceptance and safety
- 5) Sensitivity to the concerns of the community

6.7.4. The 2004 FAA report to the United States Congress on non-military helicopter noise produced the following recommendations [4]:

- 1) Additional development of models for characterizing the human response to helicopter noise should be pursued. This recommendation has been incorporated into the Rotorcraft Research and Development Initiative for Vision 100 – Century of Aviation Reauthorisation Act. NASA, FAA, and the rotorcraft industry have defined a 10-year rotorcraft research and development plan that includes the study of psychoacoustics. It is proposed that the research will determine human annoyance levels due to helicopter noise, both in its native condition and synthetically modified. Studies would be conducted to uncover neglected characteristics of noise and develop a refined metric that is more representative of the true human response.
- 2) Further operational alternatives that mitigate noise should be explored.
- 3) Emergency helicopter services should be exempt from restrictions.
- 4) Helicopter operators and communities should develop voluntary agreements to mitigate helicopter noise.

6.7.5. The Regional Helicopter System Plan for the Metropolitan Washington Area was carried out in 2004 with the aims of [109]:

- 1) ensuring the current helicopter system meets the regions transportation and public service needs,
- 2) help reduce community noise problems by better management,
- 3) establish land planning guidelines for heliports and
- 4) to document the relationship between the transportation and economic well-being/public services in the area.

The report created the following recommendations:

- 1) Create a program to collect helicopter activity data.
- 2) Establish a permanent helicopter working group.
- 3) Create a centralized and formal system to address helicopter noise complaints.
- 4) Establish a program to support helicopter operator and market needs.
- 5) To address zoning issues.

6.8. Options for the improvement of the management of helicopter noise

6.8.1. Consultative committees appear to be successful in addressing the community's concern about helicopter noise. They are successful because the public feels that the problem is being addressed and it provides a neutral platform from which to influence operators to change procedures.

6.8.2. When a complaint is received, a prompt response is essential to demonstrate environmental awareness. It is thought that a swift response will prevent the complainant becoming a repeat complainant.

6.8.3. Repeated contact from the operator to the complainant after a complaint is registered is thought to reduce the likelihood of the person making a repeat complaint.

6.8.4. There is no central point for collecting and analysing information about complaints. The CAA acts as the focal point for environmental complaints and has records of complaints received but many complaints are directed at operators and the MOD. A central data collection system for collating complaints from all sources could help indicate specific problems with a view to inform the operator responsible so they are aware of they are causing a problem. In Australia a monthly report of complaint statistics is sent to stakeholders and this could also be done: If the industry is aware of who is causing the problems, this may pressure the noisier operators to look at other mitigation procedures.

6.8.5. Caution should be employed when using complaint statistics for the estimation of the scale of the problem of helicopter noise. A public survey should be carried out to inform the industry and the public about the extent of the helicopter noise problem in the UK. The study would have to take into account the socio-economic and cultural conditions that prevail and the type of helicopter activity.

6.8.6. Airservices Australia published a guide entitled '*Environmental Principles and Procedures for Minimising the Impact of Aircraft Noise*' (see 7.6.6) which lists a hierarchical approach minimising the impact of noise on the community with the most preferred procedures for helicopter operations given first. A similar guide could be produced and publicised.

6.8.7. In Australia "Fly Neighbourly" agreements are sometimes successful and in the USA, as a result of the Washington report on helicopter noise, helicopter operators are encouraged to develop these agreements. This is an approach that could be encouraged more in the UK.

6.9. Noise prediction and modelling

6.9.1. Noise mapping at airports for fixed wing flights has been conducted for many years. These maps use data obtained during noise certification of the aircraft as a basis for its noise level and apply propagation algorithms averaged over a long time period [115]. However, it should be noted that ECAC Doc 29 specifically excludes helicopter noise and the FAA INM is the only commercially available noise model with a limited helicopter capability. Given the large number of flights at major airports and average meteorological conditions over a long period, these maps produce a good indication of the noise around airports from fixed wing aircraft.

6.9.2. Although some limited information on helicopters is now included in the some noise models, see [110], this approach is not appropriate for the meaningful noise modelling of helicopters.. Helicopter noise is dominated by the main and tail rotor tones the details of which cannot be retrieved from civil certification data. However, INM7.0 and its database now includes more than the published certification data, e.g. 1/3 octave band spectral data and utilises these in the propagation algorithms. Understanding the nature and propagation characteristics of these tones is central to capturing the helicopter's distinctive signature. It is this distinctive signature that contributes to noise complaints. Another factor to be considered when trying to capture helicopter source noise data is its directional variation. For example, helicopter noise heard at long and

medium range during low flying activity emanates from the plane of the rotor, and not from underneath as measured during civil certification. Helicopters are also louder to the front and on the advancing side of the main rotor blades.

6.9.3. Another important factor with regard to helicopter noise is that complaints usually arise from individual flights, as opposed to the average of a large number of flights as in the case of fixed wing aircraft around a busy airport. This has an important impact on the way in which the propagation of the noise should be modelled. In the case of individual flights, environmental factors such as wind, temperature, ground impedance and background noise play an important role in determining how the sound travels and how it is perceived.

6.9.4. In particular the following give rise to relatively large noise footprints:

- 1) Low frequency noise propagating further through the atmosphere.
- 2) Sound refracting downwind.
- 3) Sound refracting under temperature inversions.
- 4) Sound propagating over acoustically hard surfaces such as water and concrete.

6.9.5. Although modelling of civilian helicopter noise is deemed too difficult at present, the acoustic footprint of individual helicopter flights is of importance to the military. In the military sector, the tools and data are available to account for the above factors and produce accurate noise maps [111]. Comprehensive measured source noise databases are available for numerous military platforms, together with the tools to fully model the effect of all relevant environmental parameters. These tools could readily be adapted to accurately map civilian operations given accurate positional, meteorological and source data.

6.10. Options for the improvement of prediction for noise mapping

6.10.1. **Opportunities for improvement.** The EC Directive on Environmental Noise requires member states to make strategic noise maps for major agglomerations along major roads, major railways and major airports within their territories [1]. Noise mapping for helicopters is not currently conducted because of the difficulty in accounting for the factors discussed above. However, the expertise exists to make good account of these factors, particularly in the UK, and this could be exploited in future noise mapping programmes. Appropriate data on the source noise of civil helicopters, except where they overlap with military platforms, is not available and needs to be collected and/or estimated through source prediction code as a matter of priority.

6.10.2. **Recommendations on how these could be implemented.** First and foremost, a sensitivity analysis on the required level of helicopter noise modelling needs to be carried out. It needs to be determined what level of modelling can be practically implemented in the required time frames. Variables include the number of helicopter flights, and the associated positional and meteorological data available. It is also important to fully understand the limitations and inaccuracies present in any given model. Therefore, a systematic series of comparisons between high and low fidelity models, and levels of source and environmental data, needs to be carried out. As a result of this work, the best way forward for helicopter noise mapping can be ascertained. It may be that a relatively simplistic model must be used because of computational time constraints. On the other hand, it is possible that a database of aircraft noise maps created with high fidelity software given prevailing meteorological conditions, can be called upon to generate accurate noise maps in the future. This would yield the best possible solution for the noise mapping of helicopters, which is required to meet the European Noise Directive.

6.11. Summary of Chapter 6

6.11.1. Consultative committees to enable dialogue between residents, councils and the heliport operator have helped to improve understanding and acceptance by the public. The dialogue should be extended to include developers so that homes are created with sufficient sound insulation.

6.11.2. A fast and sincere response is important in keeping complainants from becoming repeat complainers. The failure to act on complaints is one of the largest causes of dissatisfaction and resentment amongst the public.

6.11.3. The CAA provides a focal point for receiving and responding to aircraft related environmental complaints from the public. However, the CAA currently has no legal power to prevent aviation solely on environmental grounds. An independent review is considering greater power for the CAA on environmental matters.

6.11.4. The CAA encourages noise complaints to be made directly to the airport operator. Problems related to noise generated on the ground at aerodromes, other than in association with the normal operation of aircraft, should be referred to the Local Authority.

6.11.5. MOD complaints are usually dealt with through the base's community liaison officer.

6.11.6. Properties close to helicopter bases, evaluated under the previous MOD Noise Insulation Grant Scheme (NIGS) scheme criteria, are unlikely to qualify for compensation.

6.11.7. BHAB codes of practice aim to increase helicopter pilots and operators awareness of environmental noise issues. Although pilots are aware of noise issues, factors such as safety are considered to be more important.

6.11.8. The Joint Aviation Authorities (JAA) represents the civil aviation regulatory authorities of a number of European States who have agreed to co-operate in developing and implementing common safety regulatory standards and procedures. Regulations governing the management of helicopter noise in Australia and the United States are broadly in line with those in Europe, in part due to the harmonisation work of the Joint Aviation Authorities (JAA).

6.11.9. Two significant European projects address noise from helicopters these are FRIENDCOPTER and the "Clean Sky" JTI. Both aim to produce a significant reduction in the noise generated by helicopters.

6.11.10. Noise maps and action plans are required by the Environmental Noise Directive on a five-year cycle. Helicopters are not excluded, though rudimentary noise mapping of helicopter noise is currently restricted to major airports. However, the accuracy of these strategic noise maps relating to helicopter noise is limited by the lack of sufficient source data and validation of noise prediction models in this context.

6.11.11. The UK has world-leading expertise in helicopter noise prediction and in the measurement of source noise from helicopters.

7. Conclusions

7.1. Extent of the reported problem of noise from helicopter operations in the UK

7.1.1. Reported problems with helicopter noise in the UK are centred on helicopter infrastructure, in particular specific heliports and aerodromes.

7.1.2. The consensus among stakeholders is that there is not currently a significant helicopter noise problem in the UK, except in a few specific areas near the busiest heliports. On the other hand, it is thought that there is increasing opposition to the development of heliports on the grounds of noise disturbance.

7.1.3. Determination of the scale of public concern about helicopter noise would require a social survey.

7.1.4. Determination of a dose-response relationship for the prediction of community response to helicopter noise would require an extensive and carefully designed study.

7.1.5. The study would need to take into account socio-economic and cultural aspects, and the type of helicopter activity.

7.2. Guidance on the management of helicopter noise

7.2.1. There is a need for a more 'holistic' approach to the management of environmental complaints from helicopters.

7.2.2. To ensure there is accountability related to environmental noise problems caused by helicopter operations, it is suggested that complaints are collected and logged in a central database from all sources including the CAA, the MOD, local authorities, operators and airfield managers. Attention should be paid to methods utilised in Australia where monthly reports on complaint statistics are provided to stakeholders.

7.2.3. The CAA provides a focal point for receiving environmental complaints from aircraft operations but it does not have any legal power to prevent aviation on environmental grounds. An independent review is considering giving the CAA greater powers over environmental matters². This 'holistic' approach would give a wider view and could identify specific problems.

7.3. Improving the handling of complaints - consultative committees

7.3.1. Well-organised consultative committees are successful in addressing environmental noise from helicopters.

7.3.2. When operated successfully, the public appreciate that their concerns are being taken seriously.

7.3.3. This is because consultative committees represent a neutral position from which to influence operators to change operational procedures.

7.4. Opportunities for improving dose-response relationships

7.4.1. Academic research is required to better understand the human response to helicopter noise.

7.4.2. Problems caused by helicopter noise are not represented by the certification parameters of helicopters.

7.4.3. Helicopter manufacturers are concerned that a gradual reduction in the certification levels would compromise helicopter performance or even refusal of type certification.

7.4.4. Annoyance by helicopter noise is not well correlated with generally accepted acoustic parameters. The reasons for this are thought to be related to three factors:

- 1) The unique subjective character of the helicopter noise not being fully addressed by the indices.
- 2) The use of long-time averaged (LAeq) parameters that do not correctly represent single events or operations that have a low rate of incidence.
- 3) The 'virtual noise' factor, which encompasses community attitudes and fears towards the operations.

7.4.5. The UK has world-class expertise in the subjective response to helicopter noise.

7.5. Recommendations for planners and developers

7.5.1. Developers need to be encouraged to enhance sound insulation in new / change-of-use builds near helicopter bases.

7.5.2. A residential planning application close to an operating heliport, when evaluated in accordance with PPG24, should not rely solely on Leq and should consider the intermittent nature of helicopter operations.

7.5.3. The UK has world-leading expertise in the field of sound insulation of residences from helicopter noise.

7.6. Improvement of predictions

7.6.1. Noise mapping for helicopters is not currently conducted due to the lack of an agreed noise prediction model in the public domain and inadequate source noise data.

7.6.2. Appropriate data on the source noise of civil helicopters, except where they overlap with military platforms, is not available, and needs to be collected and/or estimated through source prediction code as a matter of priority.

7.6.3. The UK has world-leading expertise in helicopter noise propagation prediction and in the measurement of source noise from helicopters, due to involvement in military programmes.

7.6.4. This expertise, currently only available within MOD programmes, could be exploited in future civil noise mapping.

²Department for Transport press release of 9 October 2007 <http://nds.coi.gov.uk/environment/fullDetail.asp?ReleaseID=320757&NewsArealID=2&NavigatedFromDepartment=False>

8. List of abbreviations

AAAC	Association of Air Ambulance Charities	ICAO	International Civil Aviation Organization
ACARE	Advisory Council for Aeronautics Research in Europe	IoA	Institute of Acoustics
ADO	Airports District Office	ITD	Integrated Technology Demonstrator
AGL	Above ground level	JAA	Joint Aviation Authorities
AI	Australian Annoyance Index	JSPs	Joint Service Publications
ANASE	Attitudes to Noise from Aviation Sources in England	JTI	Joint Technology Initiative
ANIS	Aircraft Noise Index Study	Leq	Equivalent Continuous Noise Level
ANO	Air Navigation Order	LFAs	Low flying areas
ANSI	American National standards institute	MCA	Maritime and Coastguard Agency
ARED	Aviation Regulation Enforcement Department	MOD	Ministry of Defense
ATC	Air Traffic Control	NAG	Noise Action Group
BHAB	British Helicopter Advisory Board	NASA	National Aeronautics and Space Administration
BVI	Blade Vortex Interaction	NATS	National Air Traffic Services
CAA	Civil Aviation Authority	NEU	(Airservices Australia) Noise Enquiry Unit
CAS	Controlled Airspace	NHS	National health service
CASA	Civil Aviation Safety Authority (Australia)	NIGS	Noise Insulation Grant Scheme
CIEH	Chartered Institute for Environmental Health	NNI	Noise and Number Index
dB	Decibel	NOTAR	NO TAIL Rotor
Defra	Department for Environment, Food and Rural Affairs	NPR	Noise preferential routes
DfT	The Department for Transport	PNL	Perceived Noise Level
DNL	Day-Night Level	PPG 24	Planning Policy Guidance 24: Planning and noise
DS&C	Directorate of Safety and Claims	Q	Disturbance Index
DUAs	Dedicated User Areas	Q.T/R	Quiet tail rotor
EASA	European Aviation Safety Agency	RAF	Royal Airforce
ECAC	European Civil Aviation Conference	SAR	Search and rescue
END	Environmental Noise Directive	SEL	Equivalent Sound Level with Threshold
EPA	US Environmental Protection Agency	TR	Tail Rotor
EPNL	Effective Perceived Noise Level	TRI	Tail rotor interaction
FAA	Federal Aviation Authority	UCAS	Uncontrolled Airspace
FAR	Federal Aviation Regulations	WECPNL	Weighted Equivalent Continuous Perceived Noise Level
HSI	high speed impulsive (noise)	WHO	World Health Organization
HYENA	Hypertension and Exposure to Noise near Airports		

9. Recommendations of London in Spin

Recommendations of London in Spin	CAA; responses to the recommendations of London in Spin
The Department for Transport should undertake a full review of the impact of helicopter movements and noise in London over the next twelve months, with the aim of putting in place a series of policy responses designed to mitigate the impact of this form of noise pollution on Londoners' lives.	Not for the CAA to action.
As part of its review, the Department for Transport and Civil Aviation Authority should investigate and then establish a mechanism to ensure that research on noise and other data on all helicopter movements is effectively collected, collated, analysed and published	The CAA will review what information is available on helicopter noise modelling and provide links via its website. A mechanism has been agreed with NATS to provide data on helicopter movements over London and this data will be published at regular intervals on the Directorate of Airspace Policy (DAP) section of the CAA website.
A single national web-site (for example, extending the role of the national noise mapping web-site), or a clearly publicised portal, should be established by the Department for Transport and/or Department for Environment, Food and Rural Affairs to give public access to data on helicopters, including movements, routes used, and places where holding may be expected.	A mechanism has been agreed with NATS to provide data on helicopter movements over London and this will be published at regular intervals on the Directorate of Airspace Policy section of the CAA website. DAP already has a well-advertised post that receives noise complaints from across the UK. The contact telephone numbers and e-mail address have been provided in the CAA's written evidence to the Committee.
As part of its review, the Department for Transport should take the lead to: make the public complaints procedures clearer, including making any telephone number universally known; that complaints are logged, co-ordinated and dealt with effectively; and that consistent data on complaints is published.	Not for the CAA to action. However, the CAA already has such a facility as described in response to Recommendation 3.
The Civil Aviation Authority should include the London Assembly and the Mayor of London in consultation, and seek amendment to legislation to make them both statutory consultees, regarding matters that have implications for helicopter noise.	The CAA already considers the Mayor of London to be a statutory consultee on matters that effect the GLA area of responsibility.
The operator of London Heliport at Battersea, in association with Wandsworth Council, should establish within 12 months a London Heliport Consultative Committee to, as a first priority, address local residents' concerns about helicopter movements and noise.	Not for the CAA to action.
The National Air Traffic Services and Civil Aviation Authority should come forward with proposals on dealing with the issue of helicopter holding at locations across London.	This is already underway as a follow-on to the London CTR review that was initiated by the CAA during 2005. NATS are currently working up proposals that will include changes to airspace classification, an extension of Helicopter Route H4 to the east and a new route south-east from Battersea Heliport all of which could help reduce the requirement for helicopters to hold.
The Department for Transport should review its guidance to the Civil Aviation Authority so that the environmental impact of helicopter noise is included within its responsibilities.	Not for the CAA to action. However, the CAA view is that civil helicopter noise is not specifically excluded from the current Guidance.
As part of its review, the Department for Transport should investigate user charging for any additional air traffic control services required for helicopters.	Not for the CAA to action. However, the CAA view is that helicopters should be treated in the same way as any other general aviation aircraft requiring transit services through a volume of controlled airspace established to protect aircraft landing/taking off at airport.

Recommendations of London in Spin**CAA; responses to the recommendations of London in Spin**

Following changes to the Regulations, the Civil Aviation Authority should impose restrictions on the use of helicopters for advertising and media so that the environmental impact can be minimised.

No anticipated change. The CAA could only take such action on safety grounds or because of an airspace restriction that has been created for a specific purpose. Current operations are being conducted within the Aerial Advertising Regulations.

The Department for Transport should submit proposals to the Treasury that would lead to a change in the finance rules to give a write down allowance of 25% for all helicopters.

Not for the CAA to action.

The Department for Transport should establish a working group including the Civil Aviation Authority, National Air Traffic Services, Metropolitan Police Air Support Unit, British Helicopter Advisory Board, helicopter/heliport/airport operators, Mayor of London, local authorities, environmental groups and any affected residents groups to: update estimates of future demand for helicopter movements; examine noise assessment and control issues; reappraise management of airspace; commission and undertake research; and, assess options for existing and future heliport provision.

Not for the CAA to action. However, the CAA recommends that it calls a meeting of interested parties in December 2007 when meaningful statistics will be available from NATS on the helicopter movements that have taken place. This will provide an opportunity for a meaningful assessment of trends.

The Civil Aviation Authority should give regard to the Mayor's London Ambient Noise Strategy when developing proposals on environmental matters, including helicopter noise.

The CAA will give due regard to the Mayor's London Ambient Noise Strategy.

The Mayor should reflect the findings and recommendations of this London Assembly report in the next review of his London Ambient Noise Strategy

Not for the CAA to action.

10. Institute of Acoustics

One-day meeting timetable

Improvement of the management of helicopter noise, IoA meeting, 6th Feb 2008

10:00	Coffee and Introduction	Chairman Geoff Kerry (University of Salford)
10:30	Defra policy perspective	Parminder Dhillon (Defra)
11:00	Helicopter noise management	Rodger Munt (QinetiQ)
11:30	Psychological aspects of helicopter noise	Kath Sixsmith
12:00	Management of environmental noise from helicopters – Local Authority perspective	Steve Mayner (Wandsworth Council)
12:30	Management of environmental noise from helicopters – RAF perspective	Bob McLaughlin Wg.Cmd. Tim Owens (RAF)
13:00	Lunch & structured discussion	
14:00	Management of environmental noise from helicopters - Civil Aviation Authority	Jim Walker (CAA)
14:20	Summary of helicopter operations in the UK	Paul Freeborn (BHAB)
14:40	Helicopter noise - what is important from a community prospective	Tony Pike (AgustaWestland)
15:10	Coffee & structured discussion	
15:40	Summaries	
16.00	End	

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