The improvement of helicopter noise management in the UK

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ABSTRACT

Central to the management of noise from helicopter operations is the awareness that community response to helicopter noise is a sociological phenomenon rather than purely an acoustic problem. For example, one problem identified in the UK is that it is often difficult to complain about helicopter noise, since it is unclear which organization is responsible for dealing with the complaint. Consequently, the Department for Environment, Food and Rural Affairs (Defra, UK) has commissioned research to summarize the nature and extent of the concern about helicopter noise in the UK, the rules and regulations governing operations, and existing procedures for handling complaints. Stakeholders contributing to this work include local authorities, the military, helicopter manufacturers, and the British Helicopter Advisory Board. This stage of the project will produce a detailed report together with a short non-technical guide. This paper summarizes the findings of this project with regard to subjective responses to helicopter noise [Work funded by Defra, UK].

INTRODUCTION

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 organization is responsible for dealing with the complaint.

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.

Current perceptions were supported by the recent London Assembly Environment Committee report (2006). That report states that there is anecdotal evidence of a growing concern amongst members of the public about helicopter noise. 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.

This paper summarizes the findings of this work with regard to the subjective responses to helicopter noise. This paper first 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. Throughout comparisons are drawn between the effects of helicopter noise with the effects of fixed wing aircraft noise.

SOCIAL EFFECTS

The 2004 FAA report to US Congress entitled, ‘Non-military Helicopter Urban Noise Study’ (FAA 2004) (henceforth referred to as the FAA report), contains a comprehensive literature review on the effects of noise on the individual. The FAA report (2004) was itself in part based upon the US military report 'Community response to helicopter noise' (US ACHPM 2000). Studies have shown that environmental noise, including aircraft and traffic noise can adversely affect classroom learning (Cohen et al. 1973; Bronzaft & McCarthy 1975; Green 1980; Hygge et al. 1996; Hygge & Evans 2000; Lercher et al. 2000; Stansfeld et al. 2001). 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 (WHO 2000). The WHO (World Health Organization) recommends for schools a maximum equivalent indoor level of background noise not exceeding 35 dBA. This is so that the average voice level (50 dBA) is at least 15 dBA above the background level (WHO 2000). 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”.

Studies carried out by Mugridge et al. (2000) at RAF Shawbury, 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 (2008) 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.

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. (1977) 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 (FAA 2004). In addition, it is found that increasing the loudness of a modulating sound by 2-5 dB produces the same change in perceived loudness as if it were a change in loudness of 10 dB (Schomer & Bradley 2000). This could be significant for helicopters indicating one reason why they are rated differently to fixed wing craft. Likewise, Defra-funded research by Moorhouse et al. (2005) on the assessment of LFN complaints concluded that 5 dB was an appropriate penalty for fluctuating low frequency sounds.

HEALTH EFFECTS

The Department for Transport in 1992 commissioned a report entitled ‘Report of a Field Study of Aircraft Noise and Sleep Disturbance’ (Civil Aviation Authority 2000). This study measured the sleep disturbance of people in their homes near Heathrow, Gatwick, Stansted and Manchester airports. 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 was 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. In 1998, a further study was commissioned by the Department for Transport 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 (DORA R&D 2000). A social survey was also carried out to help explore the marked difference between objectively measured and publicly perceived disturbance due to nighttime aircraft noise. However again it is worth noting that fixed wing aircraft would have been predominate. The UK 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.

Laboratory experiments (ANSI 2000) 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 60 dB (A-weighted sound exposure level) while in laboratory tests at 60 dB about 20 % of people were disturbed. 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 behaviorally awakened” related to SEL. The FAA agrees with this recommendation.

The WHO (2000) states that long-term exposure to noise levels exceeding 65-70 dB (24 h Leq) is known to be associated with causing cardiovascular problems. Passchier-Vermeer and Passchier (2000), commenting on results from studies carried out in the Netherlands, state that the observation threshold for hypertension is estimated to correspond to an Ldn value of 70 dBA for environmental noise exposure. Recently published work by the HYENA group (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 10 dB 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.

COMMUNITY ATTITUDES

Community attitude toward operations has an important effect on the community annoyance. Social surveys carried out by the CAA in 1982 and 1992 found that helicopters in the London area were up to 15 dB(A) more annoying at the 10 % and 20 % very much annoyed level than fixed wing craft. 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.

Fields (1995) study 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.

Leverton and Pike (2007) comment 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.

Fields and Powell (1987) 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 47 dB, then a linear relationship of increasing annoyance up to 59 dB. 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-IH "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 10 dB night-time penalty, used in the determination of DNL, is consistent with community attitudinal data (Schomer 1983).

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 7 dB penalty should be applied “to meter readings obtained where Blade–Slap was present unless meters are developed which more accurately reflect true conditions” (DOD 1977). The need for a blade-slap penalty was based on results from laboratory tests carried out by Leverton (1972). These tests, carried out in a simulated living room, showed that the presence of blade-slap increased annoyance by the equivalent of between 4-8 dBA. The US army report recognized a number of other researchers who also identified the need for a ‘blade-slap correction factor' (Lawton 1976; Galanter et al. 1977).

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 50-200 Hz band (FAA 2004). 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, “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.” (Molino 1995). Passchier-Vermeer (1994) commented, “tests have shown on average only minor differences in annoyance rating of more or less impulsive helicopter noise with the same noise levels”. 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.” (FAA 2004). Despite this, Pike (2008) disputes the efficacy of EPNL and other metrics to rate subjective response to helicopter noise. Although the ICAO report to CAN7 (1983) concluded that EPNL is satisfactory, it also states “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 (Pike 2008).

Despite objective evidence that helicopters are no more annoying than fixed wing craft, public surveys indicate a more negative reaction to helicopter noise. Leverton and Pike (2007) hold 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 10 dB dynamic range, and therefore these effects are not accounted for.

NON-ACOUSTIC FACTORS

Leverton and Pike (2007) describe 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.

It can be difficult to separate virtual and acoustic noise, as these factors are highly interrelated. Research carried out by Ollerhead et al. (1988) aimed to classify complaints and quantify the ‘virtual noise’ effect in terms of an equivalent A-weighted correction factor (Table 1). Although the research was based at general aviation airfields where mainly light fixed wing craft operated, results have suggested similar trends for helicopters.

Table 1: ‘Virtual noise’ effect in terms of a equivalent A-weighted correction factor

Non-acoustic effect	Equivalent A-weighted correction factor
Negative reaction to leisure flying	+5 dBA
Poor community/airfield relations	+10 dBA
Fear of crashes	+10 dBA
Nobody acts on complaints	+20 dBA
Aircraft are flying too low	+20 dBA

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.

The FAA report refers to a number of tests carried out by Schomer and Neathammer (1985) and Schomer et al. (1991) 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 20 dB. At the recent IoA (Institute of Acoustics) meeting at Salford, UK, Pike (2008) commented that there is a need for psychoacoustics experts to work with industry to address the unique subjective character of helicopter noise.

COMPARISON WITH LIGHT AIRCRAFT/MICROLIGHTS

In studies carried out at RAF bases investigating the management of Light aircraft and microlight noise at military airfields (Smeatham et al. 1995; Kerry 1997), 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.

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. Alongside helicopters, light aircraft are precluded from prosecution under noise nuisance. Both reports state that consultation with the public will help to engage people and breed more understanding for the operations.

SUMMARY

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.

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.

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.

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.

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

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