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THE EFFECTS AND PREDICTION OF ROTARY WING AIRCRAFT NOISE ON THE COMMUNITY

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INTRODUCTION

Helicopter operations constitute a growing problem for both civil and military aviation due to an increasing number of day and night operations, lower flying altitudes, specific noise characteristics and a general tendency to operate nearer and nearer to communities. It has been said that helicopter noise has a number of unique characteristics, which has led to numerous studies into whether or not the indicies should be weighted to reflect these features. The MOD has a noise compensation policy which has been applied successfully to fixed wing airfields. A recent NATO study (1) showed that the associated "airnoise" prediction model was comparable with those of other countries. The Environmental Noise Department of RAF IHMT has been asked to advise on whether the existing policy is in fact relevant to helicopter operations.

The RAF IHMT has been given the opportunity to investigate the features of helicopter noise characteristics, operations, metrics and interpretive criteria with respect to existing aircraft noise modelling systems and has embarked on a program for modelling helicopter noise around designated helicopter landing sites (HLS).

The Sound Insulation Grant Schemes operated by the MOD have been applied to HLS. The aim of these schemes is to give direct help to people who live in certain areas near to military airfields and who are disturbed by noise from aircraft. The help takes the form of grants from the MOD towards the cost of sound insulation of domestic homes. The noise criteria for grant aid is based on an LAeq,12h of 70dB. Where night-time flying (2200-0600 hrs) regularly occurs and exceeds 20 movements per night, a LAmax 82dB contour is also defined and the outer limits of the two contours become the extent of the scheme. The application of the scheme to our most frequently used HLS has not ameliorated the local community and, if anything, has exacerbated the situation.

The University of Ulster (2) carried out a review of three of our HLS. Sound levels were measured at various locations outside dwellings in the villages neighbouring the three sites. Locations were chosen for measurements at dwellings around the helipad both inside and outside the area presently delineated for insulation grants. For each location the values of the hourly Equivalent Continuous Sound Level (LAeq,hr) were measured over two non-consecutive daily periods of 10 hours duration, together with data on the simultaneously occurring numbers of helicopter movements. The hourly LAeq values for each measurement site was plotted against 10 log D - the distance from the helipad. Following regression analysis, the distance from the helipad at which the sound level reaches LAeq,12h 70dB was estimated.

COMMUNITY REACTION TO HELICOPTER NOISE

Ever since the HLS were established there have been complaints about the noise. The level of complaints suggests that the present criteria are not equitable when applied to helicopter noise and operations. District Councils, representing the local community, cited a working group of the Noise Advisory Council report on helicopter noise in the London area, in which it was stated that no residential area should be exposed to noise from helicopters in excess of LAeq,12h 62dB, as a criterion which should be applied to military HLS.

The University of Ulster reports (2) also commented on local reaction to HLS noise. One of the most frequent complaints from residents, some of whom accept the noise to which they are exposed with considerable tolerance, is the disturbance which results from night flying. On occasions, it is said, helicopters fly directly above some dwellings, and at such a low altitude, that residents fear their dwellings are going to suffer physical damage. Indeed, in several instances there were reports of soot being blown down chimneys, cracks occurring on chimneys, slates being dislodged from roofs and window glass being cracked or loosened. During exercises, local residents complain of considerable sleep disturbance over several hours. At one HLS residents also complained of helicopter activity disrupting services in the local church, which was of timber construction and, consequently, had poor sound insulation.

The problem with helicopter noise is that it is noticeable at much lower audible levels than a fixed wing jet aircraft, moreover, a jet usually approaches very quickly and has often passed before being registered in the mind. Helicopter noise is distinctive, so much so that many people can recognise the model type from the audible characteristics. Since helicopters are relatively slow, their sound is noticeable for longer periods of time. Typical events, recently recorded during the night-time hours, showed they were audible for more than 6 minutes. Helicopter noise can be likened to an alarm clock, which has a distinctive sound that is not excessively loud but will go on ringing until it wakes someone and is switched off. If an alarm clock gave off only a short burst of sound it would be unlikely to wake the user.

The research (3) into subjective response to helicopter noise which has been carried out in the UK, both in the laboratory and in the field, concludes that there is little difference between the annoyance of helicopter noise and that of fixed wing jet aircraft. However, some workers (4) suggest a 5dB weighting to allow for the impulsive nature of the blade slap noise.

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Schomer (5), in research on noise induced vibration and rattle and the human response, suggested a 10dB offset for small levels of rattle and a 20dB offset for high levels of vibration and rattle. If his conclusions were applied to HLS in the UK then, for a US Army Bell 208 "Hueycobra" helicopter, for example, the vibration rattle zone would extend to some 150–200 metres radius.

The UK CAA carried out a major review of helicopter noise in 1982 (6). Of the levels recorded in the noise environments researched, none were above 37NNI, or 58dB LAeq,12h, and the LAmax levels were correspondingly low at between 70-80dB. This compares unfavourably with our HLS where the minimum level recorded was LAeq 58dB. The LAmax levels ranged from 84 to 92dB, well above the 70-80dB(A) recorded around the London airports. Accordingly their conclusions must be considered in the context of the levels experienced. The main points were:

a. The Guttman Annoyance Scale (GAS) score is a good measure of annoyance due to helicopter noise.

b. The reported disturbance was consistant with previous studies over the same range of (relatively low) noise.

c. The annoyance was of the same order as for fixed wing aircraft at the same level of exposure.

It was noted, however, that in London areas, which have a 'mixed' aircraft noise exposure, helicopter operations were generally felt to be more annoying.

NOISE INDUCED SLEEP DISTURBANCE

Much of the research into Noise Induced Sleep Disturbance (7) has been carried out on young adults in a laboratory setting. It seems clear that night-time noise can affect the pulse rate, electroencephalogram (EEG) recordings and the amount of time spent in rapid eye movement sleep (REM) - even without waking. Indeed, exposure to noise during sleep can induce changes in the amount of time spent in REM sleep. Although noise in the early and middle part of the night is said to be the most disturbing, it is possible to compensate for evening noise disturbance by sleep later on during the night. Habituation does occur, although only by improved ability to sleep during noise and not to the physiological changes. Noise induced sleep disturbance can also adversely affect mood and sense of well-being, but there is no good evidence of any real effect on the subsequent performance or health of those affected, although the number of those reporting tiredness after a night's sleep is said to increase at exposure above 65 dB (LAeq). It is also said that there is increased need for a good night's sleep after a noisy day.

Levels advocated for satisfactory sleep range from LAeqs of 30dB to 60dB, with maximum peaks varying from 45-80dB(A). Some 20% of us wake during the night, regardless of the presence or absence of noise, and if there happens to be a noise event at the time it will be blamed. In general, sleep is disturbed by noise at 55-65dB(A), although lower levels induce changes in pulse rate and EEG, in noradrenaline levels and sleep level. These physiological changes do not habituate, although the ability to sleep in a noisy environment does. As for acceptable levels, it is said that 25% will be disturbed by outdoor LAeqs of 60dB with no more than 20 peaks of up to 85dB(A).

Although the early part of the night's sleep is the most sensitive to disturbance by noise, compensation can occur later on during the same night. Disturbance later in the night leads to an impresion of a poor night's sleep.

Noise is less likely to disturb stage 4 sleep and is, therefore, less likely to disturb children than the elderly, although it is claimed that the proportion of those who say noise is the reason for their disturbed night diminishes with age. Those exposed to noise during the day experience less REM at night and their stage 4 sleep is shifted to an earlier part of the night. There is uncertainty over the need for resotorative sleep under such circumstances.

NOISE COMPENSATION - NIGHT FLYING CRITERIA

The defining of criteria for assessing disturbance from military night flying is a complex problem. This has been solved for fixed-wing airfields by adopting criteria which take into account the degree of "regularity" of night flying. The medical input to the decision to limit this definition to three consecutive nights, when considering flying training stations, took several factors into account.

At helicopter landing sites, where there is considerable night activity, the situation is very different. This activity is on a 7 nights per week, 52 weeks per year basis, even though the 20 movements per night criterion may be reached only on a limited number of nights. Furthermore, it is likely that the activity will not be confined to the early part of the night. Both of these factors operate to reduce the possibility of physiological compensation in affected individuals. Moreover, the duration of each individual noise event is greater for rotary-wing, as opposed to fixed-wing, aircraft. This indicates that the night noise environment imposes significant stress which should be recognised in any compensation scheme.

NIGHT-TIME MOVEMENTS

It has been concluded that day time noise criteria can continue to be based on the established policy of LAeq,12h 70dB contours, but that the night-time criteria, which is based on a number of regularly occurring LAmax noise level events, was not sustainable because:

a. The range of night-time movements varies enormously from day to day.

b. The extent of the LAmax is not constant but depends how each helicopter is operated.

c. Operations can go on irregularly througout the night-time period and consequently the effects of sleep disturbance are exacerbated.

NIGHT NOISE CRITERIA

It is therefore proposed that night flying criteria be based on the average of the 8 hour LAeq (2200-0600hrs) night-time period. To compensate for the increased stress imposed on the residents, the night-time noise should be weighted by a factor of, say, 10 (as in Day-Night Levels (LDN)). An LAeq criterion level has not yet been chosen but comparisons are being made with the fixed-wing night-time criteria. The size of the night-time contour will depend on the number of night-time movements, but will only become effective when the resulting contour is greater than the day time contour. Thus, all the variabilities found in rotary wing noise environments are catered for.

MODELLING OF HELICOPTER NOISE

At present there are no internationally or nationally accepted methodologies for predicting the noise climate around either civil or military HLS. The National Physical Laboratory (NPL) is contracted by the MOD to develop a suitable computer prediction program for RAF IHMT. The essential components of any program of this sort are the definitive data on the noise source and the modelling of how helicopters operate into and out of HLS.

The modelling is being planned as an extension of the RAF IHMT's Airnoise suite of programs. Similar algorithms to those used for the fixed wing prediction model, to account for the variety of noise attenuation mechanisms, will be tested, such as wave divergence, atmospheric absorption and lateral attenuation. Lateral attenuation (the combined attenuation due to ground, meteorological, flight direction and main tail rotor effects) will, due to the complexity of the interaction between the phenomena, be the most difficult to model.

The helicopter types which will initially be included in the modelling program are the Wessex, Lynx, Puma, Gazelle and Chinook. A review of the available source noise data has been carried out. No data was found for the Wessex, but data was available for the other helicopter types.

Data is typically presented in terms of Single Event Level (SEL) versus Distance, which is ideal for helicopter modelling where the noise envolope is shown as a gradual increase and decrease. The FAA helicopter noise model and data base has also been extensively researched.

Much of the data was collected many years ago on outdated instrumentation and significant differences were noted between different sources. It was concluded, therefore, that there was a need to take further noise source measurements to check the accuracy of the data.

A combined team from RAF IHMT and the NPL carried out further noise source measurements, at a little-used RAF airfield during the Autumn of 1991, on the UK military helicopter inventory. Both laboratories positioned microphones to straddle the helicopter flightpaths, with measurement points 100 metres apart. A hover point was established midway between the two measurement arrays (Figure 1).

Each helicopter's height, speed, and take-off and landing angles were recorded by the NPL's video tracking system. Each aircraft was required to carry out level flight runs in both directions at 2 heights and 2 speeds. Take-off and departure and approach and landing manoeuvres were recorded. Analysis of the data is being undertaken currently by both laboratories and the results will be amalgamated and incorporated into our Airnoise model.

Not only is the data being considered in terms of LAmax versus distances, but, particularly, in terms of the SEL. Thus, for the take-off and landing manoeuvres, the whole of the noise energy involved will be taken into account. This is important when considering the overall noise impact from a HLS.

CONCLUSIONS

The MOD is moving towards a definitive policy on noise from HLS. The approach is based on average daily or night-time LAeq levels. The difference in approach from our fixed wing airfields is in the use of a weighted night-time LAeq. The advantage is that this obviates the need to define number of movements or how far a maximum sound pressure level extends.

Progress is being made with extending our Airnoise model and source noise tests have been completed.

ACKNOWLEDGEMENTS

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Figure 1: Measurement Positions.