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AIRCRAFT NOISE: MEASUREMENT, IMPACT AND CONTROL.

John Simson

Noise and Vibration Group, London Scientific Services, County Hall, London, SE1 7PB

SUMMARY

Unfortunately, wherever aircraft fly near people some level of annoyance from noise will result. The degree of annoyance can be estimated from the noise exposure thus enabling measures to be determined which can contain noise nuisance within reasonable bounds. Aircraft noise certification has been very successful in encouraging the development of quieter aircraft, but additional site related noise limits are also necessary to meet local needs. Day to day measurement at sensitive locations around an airport offers a means of ensuring that agreed noise control policies are effective.

WHY MEASURE NOISE?

Use of Noise Data

Many people seem to think that just by mounting a noise monitoring programme, noise nuisance can somehow be alleviated. Nothing could be further from the truth. Measurement of noise only provides data which can then be used either to assess the scale of the problem, determine how the environment is changing or to assess the success, or failure, on the ground of technical changes made to aircraft, or their operation, for noise control purposes. The data are, of course, also useful for planning future environmental noise control measures at the airport. Several kinds of measurement are possible, each developed for a specific purpose and often using its own noise units. Noise monitoring is an effective tool which can give assistance in minimising the detrimental effect of airport development but only if an adequate framework of noise controls are set up and it is clear how the noise data are to be incorporated.

Noise Certification

In November 1969, the the United States Government were the first to adopt Regulations which made noise emission control part of the airworthiness requirements for new aircraft. United Kingdom Regulations soon followed, based on criteria agreed through the International Civil Aviation Organisation. Noise Certification limits have steadily widened in scope and have generally reduced permitted noise levels as technology advanced. New provisions in the most recent Regulation, the Air Navigation Order 1986(1), included helicopters and now excludes only certain STOL aircraft and Concorde from noise certification requirements. Certification noise limits are dependant on the weight of the aircraft (Fig1 gives as an example the rules for helicopters), consequently an unacceptably wide range of noise emission values are to be expected if noise certification alone is to be relied upon to control the airport environment.

For certification purposes noise from new helicopters will be measured for "Take Off" at two symmetrical points located 150m to the side of the ground projection of the flightpath

at a distance of 500m from the "Take Off" point (shown schematically in Fig 1). Similarly, pairs of microphones are used for "Flyover" and "Approach" noise located 150m and 120m respectively below the flight paths.

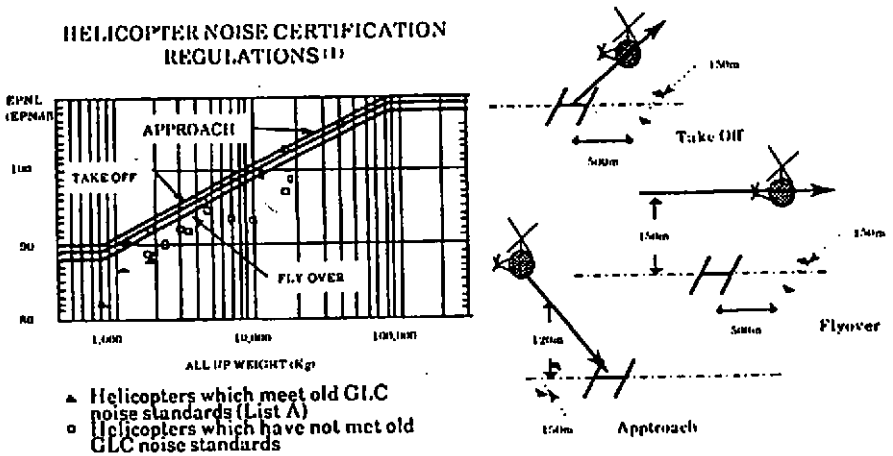

Fig1

Aircraft with normal operational weights below 5700kg (or 6500kg in the case of some "stretched" aircraft) have noise emission limits specified at a point 300m below a horizontal flyover. Larger aircraft are dealt with by more complicated regulations: maximum noise limits are set at points 120m beneath the approach path, under the take off path at 6.5km from the start of the take off run and at 650m (450m for certain modified aircraft first certificated before Oct 1977) to the side of the take off run at a point where maximum noise is heard. Different noise limits apply to jet, turbofan and propeller driven aircraft depending on the date when they first entered service. These noise limits have had tremendous effect in encouraging the development of quieter aircraft and the use of the most advanced technology on the part of manufacturers, but they do not guarantee that a noise certificated aircraft will be quiet enough to operate at a particular airport or airfield. It also takes many years for the effects of noise certification to work through and in the early stages the only effect is to halt further deterioration in emission noise levels. Most existing helicopters, for example, will just about meet the new regulations (Fig 1) and it will be many years and further tightening of the rules before reductions in noise will be achieved.

Certification noise tests are conducted under exacting meteorological and operational conditions which are rarely, if ever, those pertaining during day to day operation. The purpose of the tests are to determine the emission of a particular mark of aircraft against the appropriate international test procedure. There is no point in trying to repeat this sort of assessment during routine monitoring but the results obtained by the certificating authorities are useful to airport and heliport planners. Official noise certification test results are often available from the authorities or manufacturers and usually include the measured noise level, any corrections to be applied and the relevant noise certification limit. The examples of helicopter noise emmissions already mentioned in Fig 1 are drawn

from results determined during the development of ICAO standard, now incorporated in the 1986 Regulations. Published certification noise levels offer a good starting point for noise control measures but these must be used in conjunction with noise data from the airport/heliport site under investigation to enable noise levels to be calculated before any new development takes place.

Noise Emission and Immission

Although the basic emission characteristics are fixed by the aircraft design, and consequently generally well represented by the certificated noise emission level, the remaining variables controlling immission are dependant on the airfield and nature of operation. Noise immission will also depend on the flight characteristic (engine setting, climb angle, weight etc), the noise directivity pattern for the aircraft or helicopter, and local ground elevation.

Noise Trends

Adequate determination of long term trends in noise exposure does not, in general, require the identification of individual aircraft or the measurement of range or altitude. The London Scientific Services has used an automatic noise monitoring network at Heathrow Airport (LAANMS)[2] for extended periods at a number of sites. LAANMS does not duplicate airport noise control monitoring systems but addditionally yields information on noise trends from sensitive locations around Heathrow airport although it could be set up at any airport. Indeed, some monitoring has already taken place near Gatwick and the Trig Lane Heliport. Little attempt is made to identify individual aircraft since very often it is of no consequence to the person annoyed by noise what aircraft constituted the nuisance, although some people do complain about specific types. Monitored samples of the received noise from automatic measuring stations such as the LAANMS network can be used to determine the effectiveness noise control policies at any airport. Monitoring, rather than estimating average noise exposure does have the advantage of including effects of meteorological conditions and takes account of the way aircraft are actually flown, a facility not available from the averaged and predicted NNI methods, discussed later.

Time periods, not normally included in the noise exposure assessments, can be important, for example, about 50% of the people who report to the LSS Aircraft Noiseline complain about aircraft noise early in the morning. Long term monitoring helps to determine what factors are changing. An assessment of the trend in early morning noise at a site near Heathrow Airport shows, for example, that the Leq has been steadily increasing at one of the sample sites whilst there has been virtually no change in log-average peak noise level (Fig 2a). The number of events recorded during the early morning has increased since 1982. This would not show up on NNI because the period is outside the NNI day where the corresponding trend (Fig 2b) at this site shows a reduction in the number of events which exceed 80 dB(A). The log average noise level seems to have reached its peak in 1983 at this site, possibly indicating the start of the benefits from aircraft meeting the noise certification rules. Even a small noise reduction, taken with the changes in the number of events, would indicate a reduction in noise exposure, but this may be offset by a larger day to day fluctuation in peak noise values. In 1985, despite a small drop in log-average peak noise, the noisiest aircraft monitored at the site were louder than in 1981. A full report on long term noise monitoring near Heathrow airport is currently being prepared by LSS.

Airport Noise Limits

At major airports it is common to monitor take off noise at the edge of the built up area and relate the results to pre-set limits, usually different for day and night. In principle, similar arrangements could, with advantage, be used at small airfields and heliports as part of the noise control programme. In this case the noise monitoring system must be capable of identifying the aircraft so that policing can be effective if airfield noise limits are breached. Landing noise is not generally monitored at major airports and no limits are set for landing noise immission despite there being little difference in noise exposure from landing or take-off at many airports. At Heathrow, very large numbers of people are affected by landing noise since the most densely populated area to the east of the airport suffers noise from landing for over 75 per cent of the time. A check on landing noise levels could be important particularly with the more widespread introduction of continuous descent and managed drag approaches designed to reduce landing noise at major airports. Noise limits for landing aircraft would probably need to be defined at points some distance from the airport boundary, but could still fulfill the hopes of the Wilson Committee[3]. In general, where take off noise limits have been set at major airports they have not been revised to take account of advances in aircraft design. Such revisions, which permit more stringent control, would ensure that aircraft are operated nearer their lowest potential noise immission for the community. There is little justification for the failure to review airport noise limits or to set landing noise controls. Both measures were advocated by Wilson in 1963[3] and more recently in the report on the Stansted Airport and Terminal 5 Inquiry. Manchester airport has for many years used differential noise limits and a system of landing charge discount for quiet aircraft.

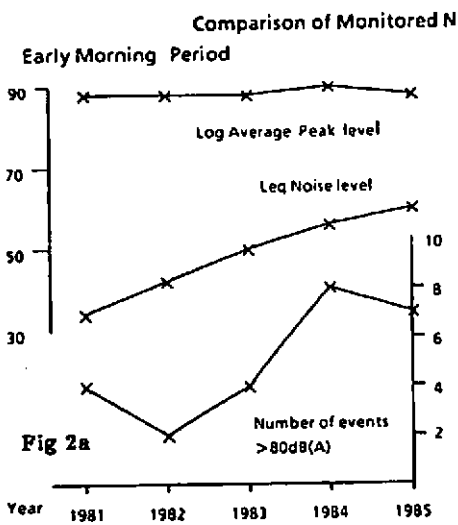

Fig 2a

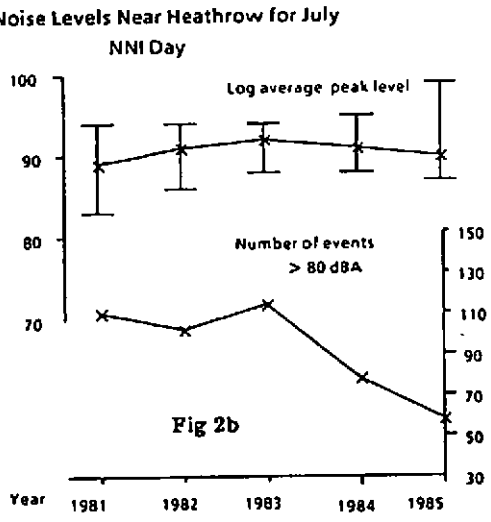

Fig 2b

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Without knowledge of the relationship between the social response to aircraft noise and some measure of noise exposure it is impossible to make decisions properly concerning airport development which reflect the needs of the community. NNI was first developed for the Wilson Committee[3] and despite serious shortcomings is still widely used as the predictor for noise nuisance near airports and airfields. It has also been used for heliport design in the absence of a better noise/annoyance correlator for helicopters. Criticisms of NNI centre mainly on the calibration of NNI, its averaging process using the "average mode concept" and the exclusion of substantial periods of time when aircraft may be operating. Average mode assumes, for the purpose of calculation, the same average distribution of runway usage, take-off and landing directions and aircraft types in one day as were actually operating for the daytime period 0700- 1900 between mid June and mid September.

Several social surveys, the main ones being around Heathrow Airport, have been used to relate annoyance to noise exposure expressed as NNI. All show that noise annoyance does not suddenly begin at a given noise exposure. Some people are annoyed by quite low noise exposure values, whilst others never become concerned by aircraft noise. As noise exposure increases, so does the percentage of the exposed population who are seriously annoyed; the relationship in Fig 3 is drawn from work by Richards[4]. There is little

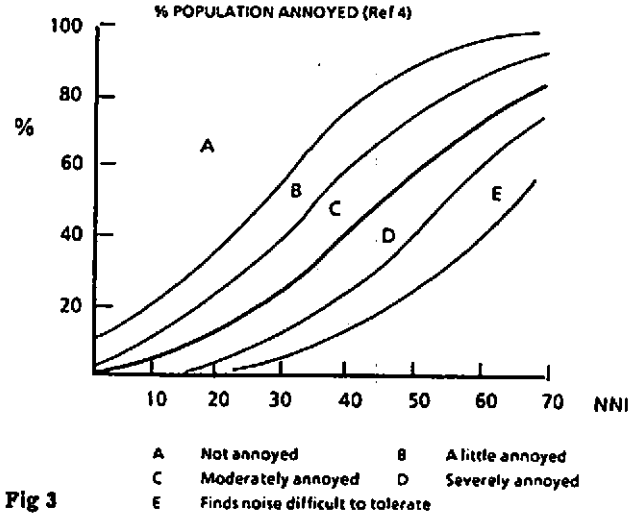

Fig 3

justification in the argument which is often put forward that annoyance from aircraft noise only begins at 35NNI where already 30 per cent of the population at Heathrow would consider themselves seriously annoyed. Recent work by the Civil Aviation Authority[5] has indicated that NNI may underestimate the nuisance caused by "quiet" aircraft (most GA and helicopter movements would fall into this category) suggesting L_{eq} as the preferred unit but again the long term averaging may pose problems. The latest research which

advocated the use of L_{eq} confirms that there is a significant level of annoyance at quite low noise exposures, with as many as 90% of people being at least a little annoyed when L_{eq} noise levels reach 60 dB(A) which is roughly equivalent to 40 NNI. Experimental relationships between L_{eq} and annoyance score indicate a more rapid increase in annoyance for L_{eq} noise exposures in excess of about 55dB(A)[5], but this cannot be used to justify a cut-off point. Instead, annoyance increases even more rapidly with noise exposure as the noise exposure itself increases. Neither NNI or L_{eq} take into account background noise and it is often argued that aircraft operations in an area where there is little other noise would cause more annoyance. Evidence to support this view is scarce however, and it is uncertain what allowances should be made for the effect of background noise when considering the annoyance caused by general aviation.

NOISE CONTROL

Legislation dating back to the Civil Aviation Act, 1949 and Air Navigation Act 1920 broadly prohibit actions for nuisance arising from airports or airfields and civil aircraft in flight. It is therefore essential that particular care is taken by the aircraft industry, and by planners, to ensure that the special protection enjoyed by the aviation industry does not lead to serious environmental noise problems. The great progress which has been made in noise certification has already been acknowledged, but there remains a need to ensure that the operations which take place near a community are governed with the specific existing and long term needs of that community in mind. Future developments in aircraft technology and the scale of operation should be catered for, so should the possible changes in the community itself. Environmental boundaries must be identified and expressed in a way which can identify for aircraft operators the scope for expansion whilst safeguarding the amenity of the area. It is just not good enough when an airport or heliport has been developed in an area which is not susceptible to noise for the local authority then to permit unsuitable developments nearby. Similarly, an airport which has been developed with a clear statement of what level of noise is tolerable should not expect to be permitted to increase its level of activity or to introduce new aircraft which, even though they may be noise certificated, could produce higher noise immission. Each airport or heliport has, in effect, an "environmental capacity".

Planning and "Environmental Capacity"

There is a sad history at Britain's major airports of development, both of the airport itself and the surrounding area, to race ahead until the environmental conflict becomes almost intractable. A better approach would be first to decide what is an acceptable aircraft noise environment for the area, or more specifically determine an acceptable noise exposure boundary. The earlier paragraph dealing with noise nuisance shows that wherever people and noise come together then some of the people will be annoyed to a greater or lesser extent, so it is very unlikely that nuisance can be completely avoided. However, it should be possible to draw a boundary within which a given noise exposure would probably be acceptable. In practice a number of boundaries for different noise exposures may need to be considered relating to different kinds of land use. Once the noise exposure boundaries have been decided this can be translated into operational terms expressed as a number of aircraft movements and average noise emission. Up to this point there has been no direct reference to the noise generated by any aircraft which may use the airfield, the considerations have concentrated on the "environmental capacity" which may be available. Aircraft which can operate within the "environmental capacity" must be identified. To be of use to the operators of the airfield the environmental capacity can be re-stated in terms of aircraft type, which governs noise emission, and movement numbers.

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The known noise emission characteristics of an aircraft type can be used as the principle guide to its potential acceptability at any particular location. Noise monitoring can relate noise emission, as determined for certification purposes, and noise immission for a particular operational pattern at the airfield. Limits set in terms of seating capacity, or aircraft weight do not offer the most effective means of containing the environmental noise of an airport or heliport. There is no guarantee that even aircraft with fewer seats than the limit will necessary be quiet and heavy aircraft with good noise performance could be unnecessarily excluded. Certificated noise values, that is those measured under the certification procedures, not the limits set in legislation, should be used to decide whether, or not, a particular type of aircraft will be acceptable.

The simplest way of using noise data is probably to categorise aircraft into groups according to their noise emission. Table 1 gives a classification adopted by tyhe GLC for helicopters and relates to the old "List A/List B" scheme. Overall levels of activity for probably no more than two noise categories can easily be determined where the number of movements made by aircraft in each group is weighted according to average noise level. Such an arrangement will be imposed at the London STOL-port and similar arrangements have proved successful at heliports[6]. At many GA airfields continuous use of the circuit by trainee pilots can be the cause of additional serious nuisance. Where this occurs, the number of circuits flown must also be adequately reflected in the movement figures. Special attention will also have to be paid to locations which are only affected by circuit flying. Routine noise control can be effected without extensive monitoring by using the movement log including information on aircraft type. However, peak noise limits are also required at sensitive locations and noise monitoring on a day to day basis may be required for "policing" purposes.

Table 1

New Noise Category	Take Off (Noise Level in EPNdB*)	Landing (Noise Level in EPNdB*)	Flyover (Noise Level in EPNdB*)	Equivalent Old GLC Listing
1	Level ≤ 85	Level ≤ 89	Level ≤ 88	"List A"
2	85 < Level ≤ 90	89 < Level ≤ 94	88 < Level ≤ 93	"List A"
3	90 < Level ≤ 95	94 < Level ≤ 99	93 < Level ≤ 98	"List B"
4	95 < Level ≤ 100	99 < Level ≤ 104	98 < Level ≤ 103	"List B"
5	Level ≥ 100	Level ≥ 104	Level ≥ 103	"List B"

*From ICAO CAN 7 Test

"Day to Day" Noise Monitoring

Estimates of long term average noise exposure are essential in determining what aviation activity can reasonably be tolerated and offers a means of assessing the nuisance that might be caused. Noise exposure, however, particularly as expressed in NNI or a long term averaged L_{eq}, is not a suitable parameter for day to day control purposes. Selective random monitoring of peak noise levels at sensitive locations gives an early warning of particular aircraft or operators who may be failing to have sufficient regard to noise

nuisance. Where a substantial number of movements are expected airport noise limits should be considered along with permanent noise monitors. Noise due to landings should not be ignored. The use of differential limits, perhaps using the charging methods adopted at Manchester International Airport, which reflect the noise capability of groups of aircraft whilst giving the noisier aircraft sufficient scope to operate within the "environmental capacity" also encourages the quieter aircraft to achieve their noise potential. Control of night movements will usually be required, probably by curfew and by using stricter noise limits which reflect sleep disturbance criteria.

CONCLUSION

Noise from any form of aviation can cause serious disturbance against which there is no legal recourse for damages. People living near airports and heliports must then rely on control measures which can accommodate developments in the type and number of aircraft using the facility. Noise monitoring, local noise limits for both take-off and landing and the use of information from noise certification tests can all be used to assist in effective long term noise control.

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The views expressed are those of the author and not necessarily those of London Scientific Services or the LRB.