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Study of The Adverse Effect of Aircraft Noise in Nigeria & Discovered Solutions

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Abstract—This paper reports on the noise pollution generated by aircrafts, the effects of the pollution on the people living around the airports. Ways to calculate the noise generated by the aircraft was also discussed so as to know the annoyance rate of the people around the airports. Finally some solutions were discussed which will help to reduce the noise of the aircrafts thereby reducing the pollution created by it.

Index Terms—Aircraft, CNEL, CNR, Measure, NNI, Noise, Sound.

1 INTRODUCTION

With the continuing growth of air traffic as well as the ever increasing level of urbanisation around most airports in Nigeria, the impact of aircraft noise and emissions on the quality of life for the surrounding communities has become a serious issue to be dealt with. Many residents living in close proximity to a series of large airports in Nigeria are affected by the problem that part of the air traffic is undertaken during the morning and evening hours. Also is the negative effects impacted by the noise of aircrafts on local residents at night [2].

While the effects of air pollution are well known, less attention has been paid to the effects of environmental noise on health. Noise is a public health issue because it can produce annoyance, reduces environmental quality, and may affect health and cognition. In particular, very little is known about the effects of environmental noise in child health. Children are especially vulnerable because noise could interfere with learning at a critical stage of their development.

All aircrafts operating in Nigeria are conforming to the Nigerian civil aviation regulation 2006 part 16 environmental protection regulations. All aircrafts must comply with ICAO Annex 16 chapter 3 or 4 requirements before granting or validating noise certification to that aircraft [1].

This paper looks at the different methods of calculating the noise level and possible solutions to reduce its effects to the environment.

2 METHODS

There are many methods used in the calculation of sound pressure levels, sound level metres can be used in the measurement of sound pressure level and are commonly used in noise pollution studies for the qualification of any noise, but especially for industrial, environmental and aircraft noise. However, the reading given by a sound level meter does not correlate well to human-perceived loudness; for this a loudness meter is needed. The current International standard for sound level meter performance is IEC 61672:2003 and this mandates the inclusion of an A-frequency-weighting filter and also describes other frequency weightings of C and Z (zero) frequency weightings. The older B and D frequency-weightings are now obsolete and are no longer described in the standard.

This study will be considering the following methods of aircraft noise measurement.

3 NOISE AND NUMBER INDEX (NNI)

Originally devised by the Wilson committee on noise in Britain (1963), the Noise and Number Index is an attempt to measure the subjective noisiness of aircraft. It uses the PNdB as a basis and additionally takes into account the number of aircraft per day (or night) as a key annoyance factor. The NNI formula is as follows:

$NNI = (\text{Average Peak PNdB}) + 15(\log_{10} 160) - 80$

Where N is the number of aircraft, the average peak PNdB is a logarithmic average of the highest levels of all overflights, and 80 is the value subtracted to take into account the findings of social surveys which showed that the annoyance factor was zero at 80 PNdB [5].

If the number of flights is known, PNdB may be converted to NNI quite easily. For instance, assuming an average peak of 105 PNdB (approx. 92 dBA) and the total number of flights to be 80,like in Lagos, the conversion would be as follows:

$$NNI = 105PNdB + 15(\log_{10} 80) - 80$$
$$= 105 + 15(1.903) - 80$$
$$= 105 + 29 - 80$$
$$NNI = 54$$

The Noise and Number Index scale runs from 0 - 60 and following the results of social surveys, the Wilson Committee assigned values of annoyance to the index as shown in the graph below. The Wilson Committee considered that exposure to aircraft noise reaches an unreasonable level in the range 50 - 60. A difference of 10 NNI corresponds either to an increase of the peak level of 10 PNdB or to a quadrupling of the number of flights in the period [4].

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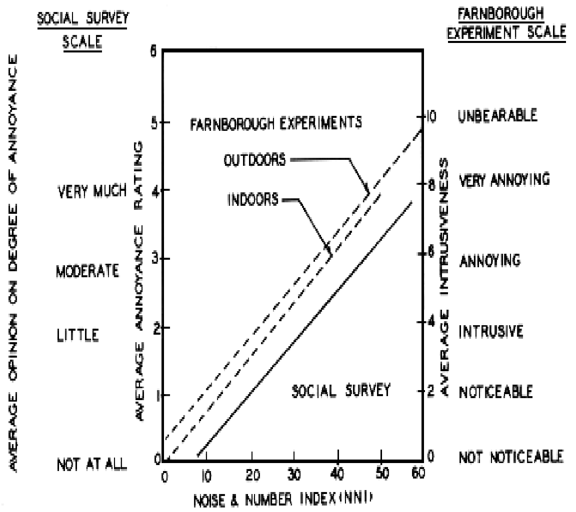

Relations between annoyance rating and Noise and Number Index obtained from social survey and Farnborough experiments. From: Wilson committee on the problem of Noise: Final Report, Cmnd 2056, London, HMSO, 1963, P. 208 [4].

4 CNR AS A MEASURE OF AIRCRAFT NOISE

A U.S. noise measurement system introduced in the early 1960's, and designed to evaluate land use near airports and predict annoyance levels from aircraft operations. Although still in use, the CNR has been superseded in some places by the more recent Noise Exposure Forecast (NEF) system (which is similar but adds corrections for duration and pure tones) and the community noise equivalent level (which is based on dBA readings to avoid computer calculation) [6].

The measurement is based on the maximum perceived noise level (PNLmax) in PNdB plus consideration of the number of flights during the day and night. The basic equation is:

$$CNR = PNLmax + 10 \log10 (ND + 16.7 NN) - 12 \text{ (dB)}$$

where PNLmax is the approximate energy mean of the maximum perceived noise levels at a given point, and ND and NN are the number of flights during the day (0700 to 2200) and night (2200 to 0700) respectively. The factor 16.7 represents a 10-to-1 weighting of night flights over day ones. In general, the CNR is related to the NEF and the NNI by the constant values:

$$CNR = NEF + 72$$

$$CNR = NNI + 56$$

As observed by R.A. Barron, in The Tyranny of Noise (p. 50) [3], the CNR "supposedly predicts whether a given noise will lead to no response, or provoke a rising degree of protest, culminating in vigorous legal action. (quoting L. Goodfriend) 'The objective is not to produce an enjoyable or even a suitable environment. It is merely to prevent complaints.' "

5 THE NOISE EXPOSURE FORECAST, NEF

A method, developed by the U.S. Federal Aviation Agency to predict the degree of community annoyance from aircraft noise (and airports) on the basis of various acoustical and operational data. As such it is not a consistent index for all environmental health problems. It is applied to determine acceptable levels for various community zoning regions.

For instance, a residential area should have a NEF of 30 or less; between 30 and 40 NEF is stated as suitable for multiple family housing, although it is not clear why a higher tolerance level should apply in this case; above NEF 40, the area is suitable for industrial and recreational purposes only [6].

The calculation is based on effective perceived noise levels (in EPNdB) for various aircraft, and considers all aspects of flight operation and time of day (weighting night occurrences heavier than daytime ones). However, weather conditions and background noise levels are not considered as yet. Increased public awareness, and subsequent decrease in tolerance of aircraft and other environmental noise, demands continual reassessment of methods such as the NEF.

The measurement is based on the following equation:

$$NEF = EPNL + 10 \log10 (ND + 16.7NN) - 88 \text{ (dB)}$$

where EPNL is the energy mean value of the EPNL and ND and NN are the number of flights during the day (0700 to 2200) and night (2200 to 0700) respectively. The factor 16.7 represents a 10-to-1 weighting of night flights over day ones. In some places, the NEF has superseded the CNR system but because it requires complex computer calculations, another system, the CNEL, has been developed based on normal dBA readings. In practice, CNEL values are higher than NEF by 35 ± 2 dB. The approximate relation of NEF to CNR and NNI is:

$$NEF = CNR - 72$$

$$NEF = NNI - 16$$

6 COMMUNITY NOISE EQUIVALENT LEVEL (CNEL)

Community Noise Equivalent Level (CNEL) measurements are a weighted average of sound levels gathered throughout a 24-hour period. This is essentially a measure of ambient noise. Different weighting factors apply to day, evening, and nighttime periods. This recognizes that community members are most sensitive to noise in late night hours and are more sensitive during evening hours than in daytime hours. CNEL depends not only on the noise level of individual approaches, but also on the number of approaches during the measurement period.

As well, the CNEL system gives a higher weighting to evening flights (1900 to 2200) and includes a table of corrections based on seasonal, residential type, previous community noise experience and pure tone/impulse

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differences. In practice, CNEL values are comparable to NEF and exceed them by 35 ± 2 dB. The total noise exposure per day (CNEL) is calculated from the equation [6]:

$$CNEL = SENEL + 10 \log 10 (ND + 3NE + 10NN) - 49.4 \text{ (dB)}$$

where ND, NE and NN are the number of flights during the day (0700 to 1900), evening (1900 to 2200) and night (2200 to 0700) respectively, and SENEL is the energy mean value of the single event noise exposure level which may be calculated from the equation:

$$SENEL = NLmax+10 \log 10tea \text{ (dB)}$$

Where NLmax is the maximum noise level in dBA and tea, is the effective time duration (in seconds) of the noise level (on the A scale) and is approximately equal to one-half of the duration during which the noise level is within 10 dB of the maximum.

7 EFFECTS OF NOISE

There are many effects of noise, they are:

3. Hearing effects.
4. Psychiatric effects.
5. Cardiovascular effects.
6. Effects on reproduction and growth.
7. Effects on sleeping.
8. Speech interference etc. [7]

8 AIRCRAFT NOISE REDUCTION

8.1 SOURCE REDUCTION

Since the initial introduction of commercial jet aircraft, great strides have been made in reducing the noise levels that they produce. Jet noise has been reduced by the introduction of first low- and then high-bypass ratio turbofan engines. In these engines, a large fan at the intake to the engine causes some air to by-pass around the central combustion chambers of the engine. By including this intermediate speed layer of air that by-passes the combustion chambers, turbulence in the engine exhaust and the resulting jet noise are reduced [8].

8.2 SOUND INSULATION OF BUILDINGS

The upgrading of the sound insulation of buildings is widely accepted as a useful technique for reducing the negative impact of aircraft noise. In many countries, sound insulation programs have been carried out to improve the sound insulation of homes, schools, and hospitals near airports. The cost of the added insulation is usually paid for by revenues from the airport such as from noise penalties added to landing fees.

These insulation programs are usually well received by residents near the airport and it is generally considered to be a good public relations gesture as well as a good way to reduce indoor noise levels. There is the added benefit that the extra insulation usually also increases the thermal insulation of the building and hence reduces the costs of heating and/or cooling the building.

8.3 LAND USE PLANNING

Land use planning is an obvious and almost universally accepted technique for minimizing the negative impact of airport noise in areas adjacent to airports. It is an especially appropriate approach in a country like Nigeria where large areas of land are not developed and there is space to take a rational planning approach. However, what seems so rational and simple does not always happen.

Land use planning near airports requires the division of land areas near airports into zones according to noise levels and the choice of acceptable uses in each of these zones. Although land use planning to minimize airport noise impact is widespread, there are many different noise measures, many different procedures for selecting zone boundaries, and many different acceptability criteria. It is usually quite difficult to determine in detail how the various regulations are applied in each country. Some apparently strict noise criteria can be quite ineffective if not adequately enforced.

8.4 CONTINUOUS DESCENT APPROACH

Engineers have unveiled a new landing plan that may help our friendly skies be a little quieter. The new landing procedure, keeps airplanes higher until they're much closer to the airport. This means planes will still be seen, but less of the noise will be heard. Instead of descending and then flying level and then descending, they just descend the whole way. This is the reduction of six, eight or even 10 decibels. The noise level of a jet engine could actually be cut in half.

9 CONCLUSION

There are significant literatures on aircraft and airport noise. They vary based on research method employed, many use comparative method to analyse the noise generated by different types of aircraft while others compare different locations (different airports). All of them discussing the same issue, of how to calculate the noise generated either by the aircraft or generated at the airport.

This study also considers the same thing, how to calculate the noise generated by aircrafts at the airports, its effects on the people living around the airport and possible ways to eliminate this problem. Different methods of how to calculate or measure aircraft noise have been discussed. These are the use of Noise and Number Index (NNI), Community noise rating (CNR), Noise Exposure Forecast (NEF) and Community Noise Equivalent Level (CNEL).

Noise and number index originated in April 1960, when a committee was appointed by the lord present of the council and minister of science under the chairmanship of Sir Alan Wilson FRS to examine the nature, source and effects of the problem of noise and to advice what further measures can be taken to mitigate it. The Wilson committee's report did not fully specify the noise and number index. A definition effectively arose from common usage after 1963 and was embodied in the second survey.

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The purpose of the NNI is to represent community reaction to the local level of aircraft noise so as to guide planning, development and noise control. It does not represent one person's susceptibility.

Community Noise Rating is used to evaluate land use near airports and predict annoyance levels from aircraft operations.

Community Noise Equivalent Level is a single number result that is calculated for a complete 24 hour period and usually made up of results taken at shorter intervals such as 5 minutes or 1 hour and then averaged over the whole 24 hours.

Noise Exposure Forecast is an aircraft noise descriptor. It is a complex composite measure of exposure to aircraft, which takes into account the maximum noise level, the duration and total characteristics of the flyover and the number of aircraft movement in both the daytime and evening period.

Noise from the aircraft has many negative effects on the people living around or near the airport that is why this study looked at various ways that the noise from aircrafts can be reduced to avoid noise pollution. Some of the ways are source reduction, land use planning, sound insulation of buildings, continuous descent approach etc.

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