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A COMPARISON OF SOME PHYSICAL PROPERTIES OF TRAFFIC NOISE MEASURES

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INTRODUCTION

Most discussion of the merits of different measures of traffic noise has, naturally, focussed on how well each descriptor correlates with disatisfaction with traffic noise. However, since none has emerged as having a clear advantage in this primary respect over the others, it becomes pertinent to ask whether the measures differ in other ways which, although secondary, may nonetheless have an important bearing on how useful they may be in practice.

One example of such a secondary attribute is the way in which a measure responds to changes in the level of ambient noise at a site. This property is likely to become increasingly important as the pressure to reduce exposure to road traffic noise continues and calculations have to be made for positions at some distance from the road concerned and where traffic flows are light at certain times of the day.

The aim of the work described in the paper was to examine how changes in ambient noise level and a number of other physical parameters affect the values of different types of traffic noise measure.

SIMULATION MODEL

The study was carried out using a Monte Carlo 'snapshot' model which simulated a single line of vehicles in which each vehicle behaves independently of the others. The principles of this form of computer simulation are well documented and only the aspects of the model which were not standard are described below.

1. Vehicle position

The distributions used for generating the first headway in a snapshot was different from the distribution used for the remainder (The 'first' headway was that which lies directly opposite the reception point). This distinction was necessary since the probability of observing a headway of given length opposite a fixed point at some random instant of time is proportional not only to its chance of occuring within the traffic stream but also to its length. If this relationship is not allowed for, the first headways would be biassed towards shorter values with a consequent overestimate of the calculated noise.

The first headway, h, was generated using the cumulative distribution function given by Equation (1):

$$P(h) = 1-e^{-h/\bar{h}}\,(1+h/\bar{h}) \qquad (1)$$

where $\bar{h}$ is the mean headway. All headways other than the first were generated using a negative exponential distribution.

2. Vehicle speeds

Two fixed distributions were assumed for vehicle speeds, one for light vehicles and another for heavy vehicles. Both were Gaussian with means of 105km/hr, 78km/hr and standard deviations of 16km/hr and 10km/hr respectively. When deriving the mean headway the mean speed of all vehicles was calculated from the relationship:

$$\overline{V}_p = (1-p)V_L + pV_H \qquad (2)$$

where $\overline{V}_p$ is the mean speed of all vehicles corresponding to a proportion p of heavy vehicles and V_L, V_H are the mean speeds of light and heavy vehicles respectively.

3. Vehicle noise

Calculation of the mean noise level emitted by vehicles at a given speed was carried out using the 'within-site' relationship given in Reference 1. The model then allowed for the variations that occur in the noise emitted by different vehicles travelling at the same speed. The standard error of the scatter about the mean line was taken to be 1.7dBA and 2.1dBA for light and heavy vehicles respectively.

RESULTS

Relationships were investigated between seven traffic noise measures:- L_{10}, L_{50}, L_{90}, L_{eq}, standard deviation L_{NP} and TNI, and five physical parameters:- traffic flow, traffic composition, road/receiver distance, excess attenuation (of noise from individual vehicles) and ambient noise level.

Examples of the results obtained are given in Figures 1-4. Each graph shows the response of a traffic noise measure to changes in traffic flow with road/receiver distance as parameter. The results refer to a composition of 20% heavy vehicles and an excess attenuation of 5dBA/100m. In Figures 2 and 4, the solid lines refer to an ambient level of 40dBA and the broken lines to a level of 20dBA; in Figures 1 and 3, the solid lines correspond to both ambient levels.

DISCUSSION

The results showed that different types of noise measure exhibit widely different patterns of response to changes in the phycial parameters. For the purposes of comparison, it is convenient to divide the measures into the following three groups.

1. L_{10}, L_{50}, L_{90}

Figures 1 and 2 show that the effects of traffic flow, road/receiver distance and ambient noise on these simple statistical measures of traffic noise are interdependent, especially at low flows.

The presence of ambient noise effectively truncates the lower end of the cumulative distribution of noise level which would otherwise be measured. An increase in the level of ambient noise from 20dBA to 40dBA thus had negligible effect on L_{10} since its minimum value was some 47dBA over the conditions considered. However, in the case of L_{90}, the effect of ambient noise was so strong that at flows below 250 vehicles/hour it becomes the dominant factor with the traffic and propagation paramters having negligible effect.

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Figures 1, 2 show clearly how traffic flow and road/reciver distance interact in their effects on the values of statistical measures. This behaviour arises from the relationship between noise level and traffic density which underlies the statistical distribution of noise from single roads. At low flows, the configuration of vehicles which corresponds to L_{10}, L_{50} and L_{90} are such that the displacements of the closest vehicles along the road are large relative to the road/receiver distance. The reduced influence of this parameter which results is most strong in the case of L_{90} but also occurs to a certain extent with L_{10}. The assumption that the effects of flow and distance are independent, made in Reference 2, would therefore appear not to be valid at low flows and positions close to the road.

2. L_{eq}

L_{eq} was found to be by far the most stables of the measures examined. Figure 3 illustrates the striking regularity with which it responded to changes in all the physical parameters: flow, composition, road/receiver distance and ambient level. This behaviour follows from the fact that L_{eq} is a simple function of the received energy which is unaffected by the temporal distribution of either the vehicles' positions on the road or the noise level. Furthermore, L_{eq} can be seen to be independent of ambient noise (at the levels considered) since it is more strongly affected by the higher noise levels than the lower.

3. L_{NP}, standard deviation, TNI

A distinctive feature of the measures which incorporate a term describing the variability of the noise is that the maximum value at each road/receiver distance does not occur at the highest traffic flow. This is because the noise levels show less variation as the flow increases. The responses shown in Figure 4 arise because L_{NP} is a composite measure of L_{eq} and the standard deviation and reflects the characteristics of both. The effect of an increase in flow is to increase L_{eq} and to reduce the standard deviation with the result that the overall change in L_{NP} is relatively small. Similarly, when the level of ambient noise is varied, L_{eq} remains unchanged but the standard deviation varies considerably at low and medium flows. L_{NP} varies in the same way.

References

1. P. T. Lewis 1977 Journal of Sound and Vibration 55 472-473. The noise generated by single vehicles in freely flowing traffic - some further comments.
2. Department of Environment and Welsh Office 1975. HMSO. Calculation of road traffic noise.

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FIGURE 1 L_{10} X

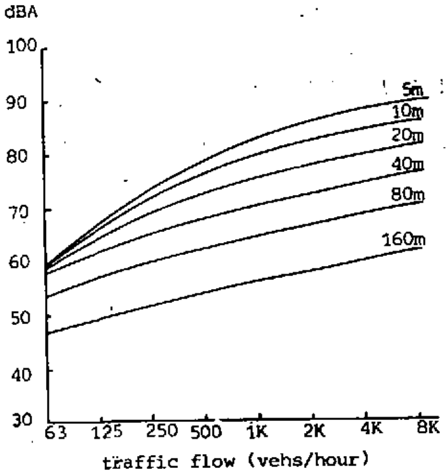


FIGURE 2 L_{90}

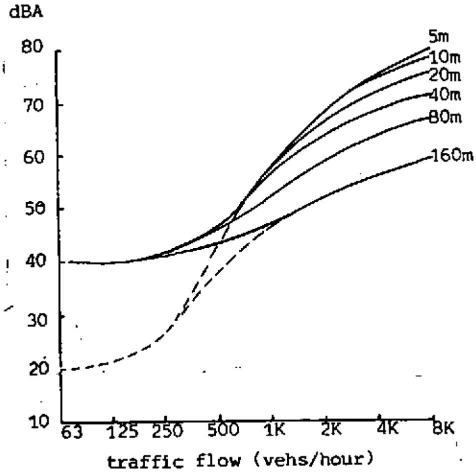


FIGURE 3 L_{eq} X

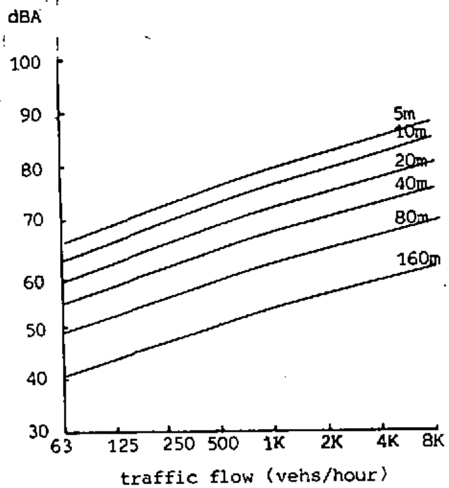
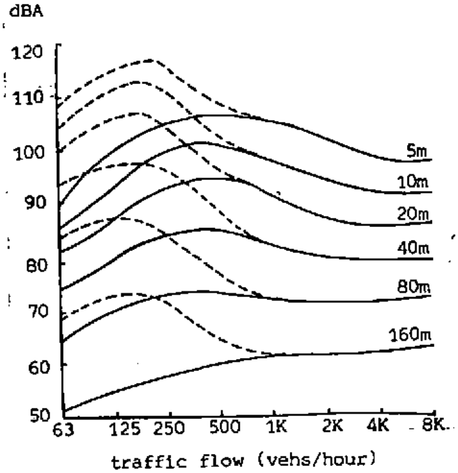


FIGURE 4 L_{NP}



X Note: these graphs do not show effects of B/G noise: see paper.