PREDICTING L_{10}, L_{50} AND L_{eq} FOR URBAN TRAFFIC NOISE

J. S. Bradley
Faculty of Engineering Science
The University of Western Ontario
London Canada

The work reported here is a small part of a larger project that has been carried out over the past two summers with the aid of students working on Ontario Experience '75 and '76 grants. The problem of predicting urban traffic noise levels breaks down naturally into two parts: (a) the prediction of levels close to the road and (b) the complex propagation of the traffic noise in an urban environment. Work on the propagation part of the problem has shown that simple methods such as "so many dB per row of houses" are inadequate, and point by point diffraction calculations for both the vertical and horizontal edges of buildings have been combined with the results of a computer ray tracing programme to predict attenuations due to arrays of apartments and townhouses. Results seem very promising, but are not yet complete. Therefore, the work reported here is limited to the problem of predicting levels close to the road.

PHASE I REVIEW

Results of the first phase of the work reported at the Toronto CAA Meeting examined methods for predicting various noise indices.(1) It was seen that in view of its simplicity, the empirical equations of Hajek's Ontario MT&C(2) method were about the best of the existing methods.

By refitting the empirical equations, using multiple linear regression analysis, new equations were obtained that produced even better results. This was not surprising in the case of the Delany equations which were derived originally from British data.

The first phase of the work thus showed that the Ontario equations were good but that the newly derived empirical equations were better. Both sets of equations were limited by the fact that they were empirical and hence were very much a product of the data base from which they were derived. There was a definite need to test the better equations with a larger amount of data, and to consider analytical equations that would better allow a fuller understanding of the noise generating process.

ANALYTICAL EQUATIONS FOR L_{eq}

An analytical equation was derived for predicting L_{eq} values. Although derived in a little different manner, it has subsequently been discovered to be essentially the same as an equation produced recently by BBN.[3] The equation was obtained by first calculating the L_{eq} for one vehicle by integrating over one complete pass by using an appropriate source level. Additional vehicles were then considered by adding the effects of each single vehicle.

Differences occurred between the present work and that of BBN in the use of vehicle source levels. After finding that their method overpredicted by about 4dBA, BBN arbitrarily subtracted 4dBA from all vehicle levels with some arguments about the shielding of one vehicle by another. It is interesting to note that when 4dBA is subtracted from the BBN expression for car source levels, it gives results almost identical to those of Olson at NRC.[4] As there is quite good agreement in the literature for car source levels at urban speeds, both the Olson and BBN-4dBA results were used for cars in this work. There is much less agreement in the literature for truck noise levels, due largely to the many types of trucks. The appropriate truck source levels were therefore determined by choosing values that minimized the error in the L_{eq} predictions at each speed. As an example, the value was 80.0 dBA for heavy vehicles at 30 mph and at a distance of 50 feet.

Analytical expressions for L_{10} and L_{50} were not attempted because their derivation is not such a clear cut problem. One must first make assumptions about the type of distribution of noise levels. These assumptions are approximations which must immediately be questioned, and it seems equally acceptable to consider empirical equations.

EVALUATION OF THE EQUATIONS

The more promising prediction methods have now been evaluated using 160, thirty-minute traffic noise recordings. The methods that were evaluated were: the Ontario MT&C method for L_{10}, L_{50}, and L_{eq}, the BBN equation for L_{eq}, and the new version of this equation. In addition, coefficients for the new empirical equations of the Delany form have been obtained by multiple linear regression analysis of the complete 160 data points.

Table 1 shows the standard deviations of the measured values about the predicted values.

All methods were reasonably accurate, but the Ontario equations for L_{10}, L_{50} and L_{eq} were inferior to the empirical equations developed in this work. This is probably largely due to the fact that the Ontario method was developed to predict highway noise, whereas the present data is strictly urban traffic noise. Of the four methods of predicting L_{eq}, the new empirical equation was the most accurate predictor followed very closely by the new version of the BBN analytical equation.

Figure 1 plots a range of predictions for three L_{eq} predictions equations: The Ontario, the new empirical, and the new version of the BBN. This figure illustrates that in more extreme conditions the three predictions differ quite greatly. For the case of 10% heavy trucks, the three methods are all quite close, (within about 1dBA). For the case of 20% heavy trucks, differences of up to about 2dBA occur. For the case of no heavy trucks, differences of up to 6dBA occur. Thus, the small overall standard deviations of 2 and 3dBA hide the much larger possible prediction errors in particular cases. More consideration must be given to the basic form of empirical equations and the range of the data base.

NON FREE FLOW TRAFFIC

It is frequently questioned whether prediction schemes are as accurate for non free flow traffic. Ten recordings were made for the extreme case of intersections with traffic lights. The results showed a small tendency for most methods to overpredict, but with only 10 points and such small effects, it can only be concluded that all of the methods are reasonably suitable for predicting noise levels at intersections with traffic lights.

GRAPHICAL PREDICTION METHODS

In many applications, simple graphical prediction methods can be extremely useful. Consideration was given to presenting the BBW type equation graphically. Because the effects of the three main variables (Cars/hour, Trucks/hour, and Speed) are not readily separable, a simple easy to use graphical prediction scheme is most easily obtained from the new empirical equation for L_{eq} as illustrated in Figure 2. Here, L_{eq} is plotted versus total vehicle flow rate for a range of values of percentage of heavy vehicles. Finally, a small correction is added for speeds over 30 mph.

USES OF THE ANALYTICAL EQUATION

One very valuable use of the analytical prediction equation concerns determining the effects of reduced vehicle noise levels. The resulting reduction in L_{eq} values is very easily calculated for various combinations of reduced car and truck levels. Several examples were calculated and showed that the commonly proposed case of reducing only truck levels would provide satisfactory reductions in overall traffic noise levels only at sufficiently high percentages of heavy trucks.

CONCLUSIONS

To conclude, several methods of predicting traffic noise levels have been evaluated, using a large number of urban traffic noise recordings. New empirical equations have been found to be more accurate than the Ontario MT&C methods. An analytical equation for predicting L_{eq} values similar to that derived by BBN has been found to be quite accurate when vehicles were considered only in two type groups, and using suitable vehicle source levels. A definite need is seen for more vehicle noise data under various real operating conditions to use with such analytical prediction equations. Intersection noise levels were found to be predictable with almost the same accuracy as free flow traffic noise, and a simple graphical prediction method for L_{10}, L_{50} and L_{eq} was obtained from the new empirical equations.

REFERENCES

(1) "Report on the Prediction of Urban Traffic Noise Levels Close to the Road". J. S. Bradley, U.W.O. Fac. of Eng. Report SV-75-3.

(2) "Ontario Highway Noise Prediction Method". J. J. Hajeck, Ontario Ministry of Transportation & Communications Report RR197 (1975).

(3) "Highway Noise Propagation and Traffic Noise Models". B. A. Kugler, G. S. Anderson, D. E. Commins, A. Piersol, NCHRP 3-7/3 (1974).

(4) "Survey of Motor Vehicle Noise". N. Olson, J. Acoust. Soc. Am., Vol. 52, N. 5 (Part 1), pp. 1291, (1972).

TABLE 1 STANDARD DEVIATIONS ABOUT PREDICTED VALUES (dBA)

	L_{10}	L_{50}	L_{EQ}
ONTARIO	3.39	3.86	3.17
NEW EMPIRICAL	2.05	2.12	1.92
BBN	-	-	2.87
COBB/BBN	-	-	2.02

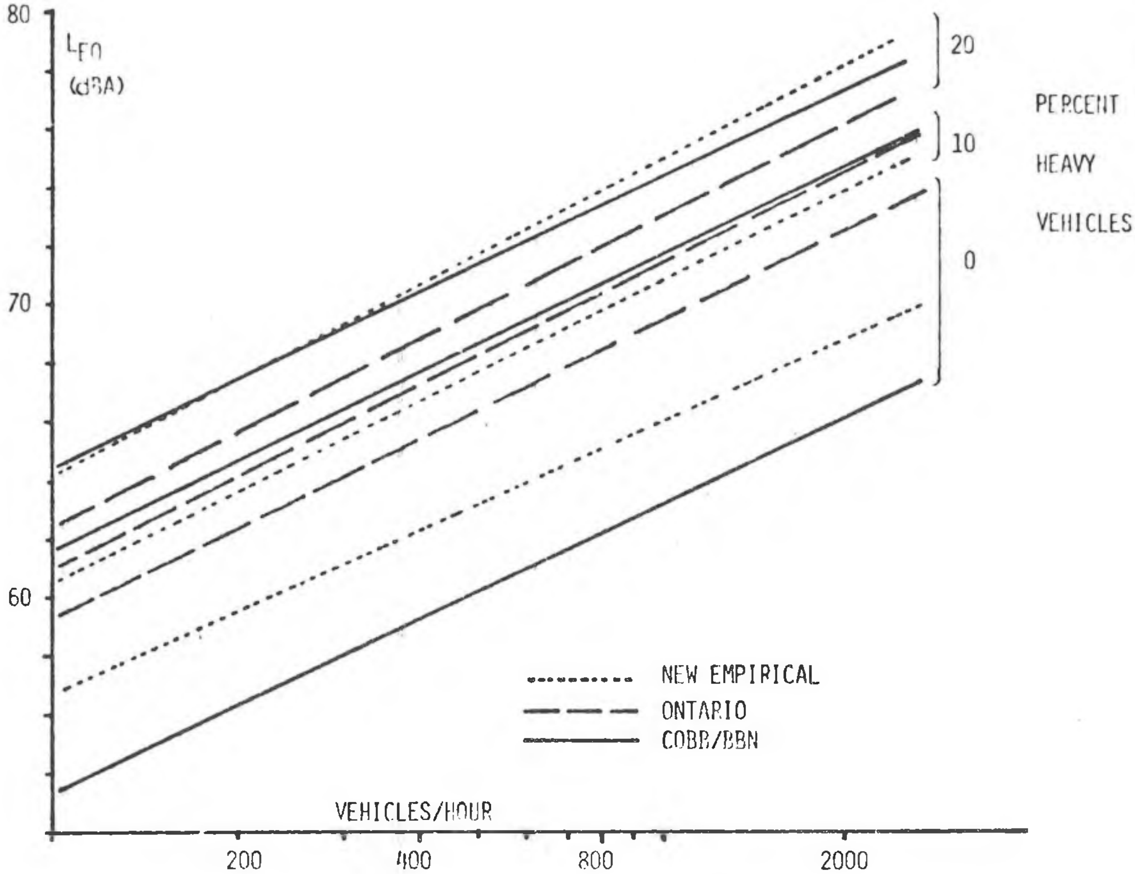

FIGURE 1 COMPARISON OF PREDICTION EQUATIONS

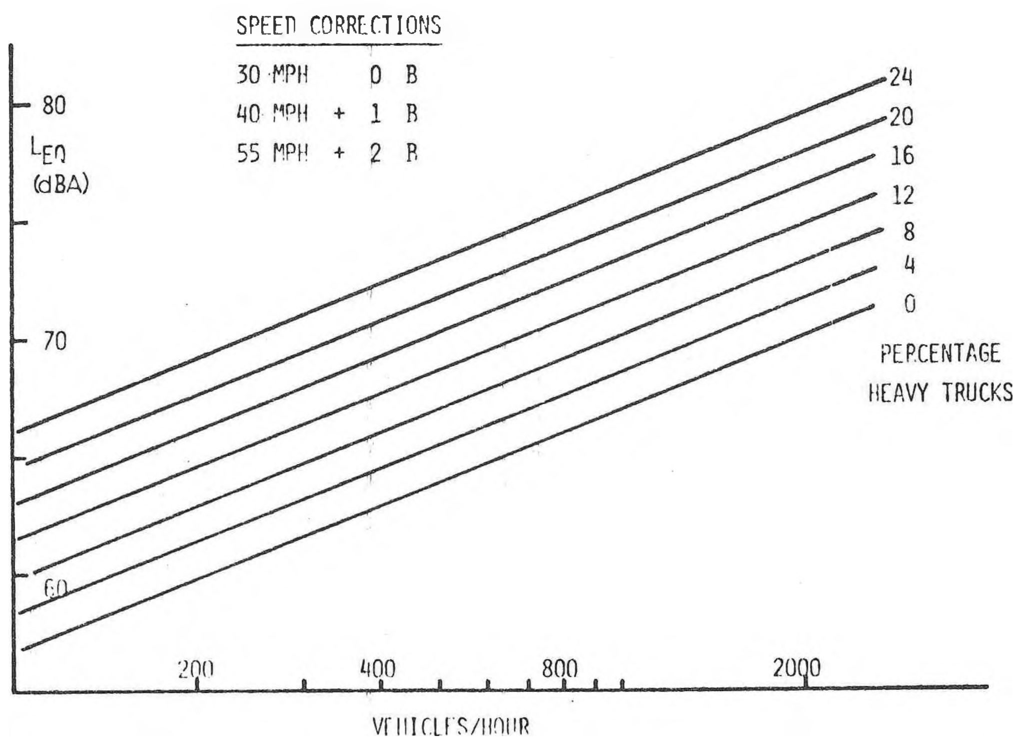

FIGURE 2 NEW GRAPHICAL L_{eq} PREDICTION METHOD