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PREDICTING AND MAPPING URBAN ENVIRONMENTAL NOISE

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1. SUMMARY

This paper reports a method that has been developed at JURUE for predicting and mapping the levels of ambient environmental noise over large urban areas. The method uses an empirical model that predicts the mean L_{10}, L_{90} and Leq noise index levels for any 1 km. grid square area, on the basis of the type of land use activity within it and the density of its road network. The model has been tested and calibrated in the West Midlands. Its main application is to strategic level urban planning contexts.

2. AMBIENT NOISE MAPPING AND PREDICTION MODELS

Local authority environmental and planning departments are increasingly being asked to prepare ambient noise maps of their areas. These are used in strategic level development plans and large scale development control ('EIA') contexts(1,2).

Mapping environmental noise is technically more difficult than mapping other environmental problems such as air pollution or soil contamination. Within a typical urban area, ambient environmental noise levels vary rapidly over short distances and short periods of time. This means that noise maps cannot be drawn up simply by 'interpolation' of noise survey data, because it is not practicable to make enough measurements for the data to be representative of the area covered(3).

For this reason 'predictive' models are used. Most environmental noise prediction models however only deal with 'single' noise sources such as roads, airports, and individual factories; these are not suitable for mapping noise in typical urban situations where the environmental noise is the result of a combination of many different and often unidentifiable sources.

The alternative is to use 'area-based' models that predict the typical noise levels of certain specified types of area(4). To date, however, these models have lacked a systematic, scientific basis.

3. DEVELOPMENT OF THE JURUE MODEL

To remidy this, the JURUE research project was set up explicitly to develop an area-based spatial prediction model meeting the following criteria:

(a) **Practical:** it must be quick, easy and inexpensive for a local authority to use, taking readily available input data and giving a 'mappable' output.

(b) **Technical:** it must be based on area types which are quantitatively and explicitly defined and zoned.

The level of ambient environmental noise in an area is primarily a function of the degree and type of human activity carried on within it. This is a general principle encountered in the spatial analysis of pollution(5,6). For noise, the important noise generating activity characteristics are commercial, industrial and residential land uses and the road network. Open space acts as an attenuator of noise.

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These considerations have led us to classify areas into nineteen distinct types, based on:

(a) **Land Use** expressed as the percentage of an area occupied by commercial, industrial, residential and open space land;

(b) **Road Network Density** expressed as the number of road junctions per unit area. These nineteen area types are shown later in Table 1.

Areas were designated on a 1 km grid square (Ordnance Survey) base. This gives zones that are large enough to avoid major cross-boundary interactions and small enough to be reasonably homogeneous in their area type characteristics.

4. MODEL TESTING AND CALIBRATION

Validation and calibration of the model was carried out through a field survey of noise in the West Midlands Metropolitan County. Measurements were obtained from 700 sites selected from within a sample of grid squares, chosen to cover the full range of area types in the classification system. Short-term noise monitoring methods were used to obtain L_{10}, L_{90} and Leq noise index levels at each site for the 'working weekday' period. Sites were selected on a controlled random sampling pattern at a density of 20 sites per km. grid square.

Conceptually a model of the kind described here is founded on the hypothesis that the spatial variationin observed urban noise levels is statistically significantly associated with the spatial variation in area types. The validity of this theory has been tested by applying the variance ratio 'F-test' to the experimental data obtained from the field survey. This test compares the site-to-site variance in noise index levels **within** the area types to the variance in noise levels between the different area types. The value of F obtained in this way was significant at the 0.1% level, thus validating the theoretical basis of the model.

Calibration was achieved by assigning 'typicial' noise index levels to each of the area types. This was done using the mean of the working week-day noise index levels of all the sites observed within each area type.

In the course of validation and calibration it was found necessary to 'correct' the observed working weekday noise index levels to account for the effects of windspreed on noise. This was done by a systematic investigation of the day-to-day variations in both noise index levels and mean windspeeds. It was found that winds of Beaufort Scale 6 can raise the background L_{90} level by up to 8dBA. A prediction model was developed relating Beaufort Scale windspeed measurements to the resulting elevation in noise index levels.

5. DISCUSSION OF RESULTS

Table 1 shows the output of the area-based prediction model in matrix form. The 'cells' give the average noise index values that can be expected on a working week-day at sites within an area of the kind specified by the matrix parameters.

The accuracy of these predictions has been checked by field surveys. These show that the r.m.s. error of the predicted area-mean noise index levels is 1.7dBA. This is equivalent to the accuracy of road traffic noise models.

Within each area typte there is a spatial variation in noise index levels which is generally statistically 'normal' with a standard deviation of between 5 and 7dBA. These are in line with the results of previous studies[3].

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Table 1

Mean Noise Levels Assigned to Area Types in the JURUE Model

Land Use		Road Network Density								
		A. Dense			B. Medium			C. Sparse		
		L_{10}	Leq	L_{90}	L_{10}	Leq	L_{90}	L_{10}	Leq	L_{90}
0.	Residential	60	56	48	56	53	46	53	50	43
1.	Industrial	63	59	54	63	61	57	*	*	*
2.	Commercial	71	68	63	*	*	*	*	*	*
3.	Open Space	*	*	*	*	*	*	46	43	39
4.	Res/Ind	65	62	56	62	60	55	*	*	*
5.	Res/Comm	57	55	50	58	55	47	60	57	52
6.	Ind/Comm	70	66	60	67	64	60	*	*	*
7.	Res/O.S.	59	56	50	55	52	47	52	49	44
8.	Ind/O.S.	*	*	*	65	63	61	56	54	50

*: Areas not found in West Midlands County

Using a base grid map of the West Midlands County classified into the nineteen area types of Table 1, a map of predicted noise levels was derived as shown in Fig. 1. The predicted noise levels have been grouped into five ranges for convenience of presentation.

From a statistical analysis of the results and field survey checks it has been shown that the chances of 'misallocating' a grid square into the wrong range category due to prediction error is less than 10%. This is not significantly more than the random statistical measurement error at this level of sampling density.

6. CONCLUSIONS

Substantial progress has been made in establishing a scientific basis for mapping urban environmental noise. Further developments are now underway to refine the road network density parameter and introduce site-identity parameters.

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Fig. 1 Distribution of ambient noise categories in the WMMC