COUNTING HOUSES: IMPROVING ASSESSMENT OF NOISE IMPACT USING THE DESIGN MANUAL FOR ROADS AND BRIDGES

KR Tompsett NoiseMap Ltd, Epsom, Surrey, UK

1 INTRODUCTION

Noise mapping software has greatly simplified the accurate calculation of noise levels arising from infrastructure projects, such as roads and railways. However, in practical terms, this is of limited benefit unless the noise impact of such projects can be assessed and presented with similar accuracy, speed and accessibility. This noise impact needs to be understandable not only to technical teams but also to the general public and other stakeholders involved in the design, assessment and planning process.

Unfortunately, techniques for assessing and presenting noise impact have lagged behind developments in noise calculation, and indeed have changed very little in the last 40 years. Even in 1974, hand-drawn maps (Figure 1) and tables were being prepared to show changes of noise level and facades qualifying for noise insulation under the new Noise Insulation Regulations 1973[1] (now superseded by the 1975 Regulations[2] and later revisions).

This paper considers why methods of noise impact assessment have lagged so far behind noise mapping and shows ways in which this could be improved.

2 PRESENT UK APPROACH TO NOISE IMPACT ASSESSMENT

2.1 Methods of noise impact assessment

Various UK and EU governmental agencies have published guidance on noise impact assessment. There are four main approaches, which can be broadly summarized as follows:

- (i) assessing the (change in) noise level at noise-sensitive receivers (NSRs);
- (ii) assessing the (change in) noise annoyance (dissatisfaction, bother, nuisance) at NSRs;
- (iii) assessing future noise levels against absolute criteria;
- (iv) assessing the monetary value of the (change of) noise level at NSRs.

2.2 DMRB Methodology

In the UK, perhaps the most important guidance on assessing the impact of road schemes is that set out in the Highways Agency's *Design Manual for Roads and Bridges*. Volume 11, Section 3, Part 7 contains guidance on the assessment of Noise and Vibration[3]. This was first published in 1992 and has been regularly revised, with the latest version being dated November 2011. It contains around 30 pages of detailed instructions on reporting the noise impact of (trunk) road schemes, but it shies away from advising on how to rank options in order of preference.

2.3 Experience with DMRB

Despite the extensive and detailed guidance, the DMRB procedures for assessing noise impact are difficult to apply, even in simple cases. A hypothetical example was presented as an assignment to 62 IoA Diploma Students in May 2014. It considers a street with two rows of ten terraced houses, one row each side of a busy and congested road, see Figure 2. Two options were presented for relieving the congestion of this road: one was to widen the existing road and the other was to build a bypass behind one of the existing rows of housing.

The students were provided with Do-minimum and Do-something noise levels for the baseline year. Their task was work out the changes of noise level and changes of noise 'nuisance' in accordance with the DMRB procedures; to count up the number of properties in each category of change; and to present the results in the standard DMRB assessment tables. They were also asked to provide an opinion as to which option had the least noise impact. Despite its simple appearance, very few students got the expected answer, and opinion was fairly evenly divided over whether the by-pass or the on-line widening had the least noise impact. Although this should have been an easy assignment, students found the opposite, with one tutor reporting that completing the assignment was 'a test of character'!

2.4 Difficulties with DMRB

The DMRB must take some of the responsibility for the students' difficulties: its advice is not set out as a procedure to be followed in a straightforward sequence, but instead it is spread over 30 pages of densely argued reasoning and instructions which need effort and practice to absorb.

Moreover, some of the advice lacks clarity. One major problem for students was what do when the change of noise level is different on the front and rear facades of a property, a common occurrence. DMRB instructs users to make the assessment for the façade with the 'least beneficial change'. However, its terminology caused many students to understand that where one façade had no change in noise level, but the other had a reduction, taking the least beneficial change meant that they disregarded the reduction in noise and they recorded 'no change'.

Calculating the change of noise nuisance was a challenge, as the procedure usually rates increase in noise annoyance from the short-term impact, whilst the reduction in noise annoyance is usually rated from the much lower long-term impact. Care is needed to ensure the right charts are applied.

3 THE PROFESSIONAL APPROACH

3.1 Assessment from noise maps

Most real projects are much more complex than the above example. They can involve thousands of building facades with complex changes in noise level, where computerized assistance is essential.

A method developed by the author's team at Atkins in 2003 for the London Road Traffic Noise Map[4] was to use GIS algorithms to overlay building outlines onto a noise map, see Figure 3, and thereby obtain the noise level on each façade. The London Road Traffic Noise Map required a count of the noise level on the most exposed (noisiest) façade, so once the façade noise levels were derived, this was straightforward to extract (Figure 4).

Obtaining *changes* of noise level is more complex because the exposure on each façade must be recorded for each scenario and the least beneficial change then extracted. This problem is solvable programmatically and an accurate result can be obtained. However, the work requires GIS software, operated by specialists, which can be costly and slow.

However, it is no longer necessary to use an independent GIS system for this, as the work can now be done in noise mapping software.

3.2 Assessment using façade noise levels

Figure 5 shows a change of noise level map for a scheme which consists of building a new link road (running east-west in the figure), thereby relieving existing roads (running north-south in the figure). The noise map makes it easy to visualize the noise changes that the scheme would bring about, although they are complex: blue and pale green colours indicate noise reduction, whilst darker green, yellow and red colours indicate an increase in noise level. Many of the houses have different amounts of change on front and rear facades, with particular intricacy around the houses because of the screening they create. It is obvious that counting changes of noise level on this map would be a difficult task.

A better approach is to generate individual receptor points around each building façade. This can be done automatically using NoiseMap five software[5] and the address of each receiver point can be extracted from the AddressPoint (postcode) database. This contains the location and address of every occupiable residential or non-residential building in the UK, including information that can be used to determine the type of building. This means that residential buildings, schools, commercial and other buildings can be identified. Next, the noise level at each receiver point is calculated from the noise model. Calculations are made for each scenario, such as Do-minimum, Do-something, baseline year, and design year, see Figure 6 for an example.

Once the noise levels are available, it is a matter of identifying the scenarios to be assessed and software can then programmatically produce the DMRB assessment tables. This process can, in practice, be quicker than creating contour maps, as fewer calculation points are required. The approach can be readily extended to other types of impact assessment, such as eligibility for statutory noise insulation, changes of noise level for Part 1 Compensation[6] claims, and the monetary analysis required by TAG[7], which is otherwise very difficult to do even though automated spreadsheets are available.

4 ASSESSMENT AND RATING OF NOISE IMPACT

4.1 Comments on the DMRB assessment tables

The DMRB sets out a variety of assessment tables that must be produced at the 'detailed' assessment stage. These are set out in Tables 1 to 3 for the scheme of which Figure 5 is part. It may be noted that there are 9598 properties within the study area of that scheme and it is required to classify these in terms of the change of noise level both short-term and long term. It is also necessary to calculate the change of 'nuisance' (bother) for both traffic noise in terms of L_{A10} (18-hour) and L_{night}, plus airborne vibration. The table showing change in traffic vibration nuisance is not reproduced here to save space.

These figures look rather alarming, with large numbers of properties affected, but having acquired all this data, the DMRB does not suggest any method of assessing the overall impact of a scheme, stating that a methodology has not yet been developed.

The problems of using changes of noise level to rank schemes are well known. For example, whether a scheme that exposes a few properties to a large increase in noise is preferable to a scheme that exposes a large number of properties to a small increase in noise; and whether the importance of a change of level is the same regardless of the noise level of the starting point.

When DMRB introduced the assessment of change of 'nuisance' (ie noise annoyance), this gave the possibility of ranking schemes according to the total number of people annoyed by noise in each of the options. This would have given a single number rating for each option. However, in the most recent edition of DMRB, this has been dropped in favour of a table showing 'change in nuisance level'. This is not much different from the change of noise level table, except that the procedure usually rates increase in noise annoyance from the short-term impact, and the reduction in noise annoyance from the much lower long-term impact. This has the justifiable effect of heavily discounting reductions in annoyance resulting from noise reductions brought about by a scheme.

However, the term ‘nuisance level’ adopted in the assessment tables is misleading: it is *not* a measure of the amount of annoyance experienced by any one person: it is a measure of the proportion of a typical *community* that will be ‘bothered quite a lot or very much’ by the noise. Moreover, because the assessment table is phrased in terms of the change in percentage of people bothered, it falls into the same trap as the change of noise level table: the starting point of the annoyance is not reported. Thus it implicitly assumes that an increase of 40 % in annoyance has the same significance whether the increase is from a base of 1 % already bothered or 60 % already bothered.

4.2 Opportunities for improvement

Rather than noise impact assessment techniques improving over time, the situation has arguably worsened with a proliferation of new indexes, such as the L_{den} and L_{night}, which add confusion rather than clarification.

The EU’s Environmental Noise Directive (END)[8] had the potential to create a paradigm shift in noise impact assessment, as indeed it did create in noise mapping, but since then it seems to have faded into a bureaucratic process. As part of the work towards the END, the Day-Evening-Night (L_{den}) index was adopted as a universal measure of noise exposure. A committee of European experts put forward a series of dose-response relationships that relate noise annoyance to noise exposure measured in terms of the L_{den}, and they go so far as to recommend that the percentage of people annoyed [%A] should be used as the preferred descriptor of noise annoyance in a population. Furthermore, they suggest that noise criteria should be set in these terms.

This gives some backing to the earlier DMRB approach of calculating the total noise annoyance of each scheme option. Total annoyance has been evaluated for the example scheme and the results are shown in Table 4. It can be seen that despite the large number of properties in the study area, the number suffering noise annoyance is much more modest and changes by a relatively small amount as a result of the proposals. Annoyance could be used as a common factor in multi-modal analysis, and indeed the controversial monetary analysis attempted by TAG is actually based on annoyance percentages. TAG attempts to reduce all factors to monetary values so that cost-benefit analysis can be adopted.

As with any type of performance indicator, there needs to be post-construction validation, to ensure that attempts to improve methodology have had the desired effect. For example, the National Roads Authority of Ireland (NRA) undertook an extensive post-construction evaluation of a number of Environmental Impact Assessments, culminating in the consultation draft ‘Good Practice Guidance for the Treatment of Noise during the Planning of National Road Schemes’[9] (December 2013) in which the present author was involved. This advises on the practical implementation of the NRA’s ‘Guidelines for the Treatment of Noise and Vibration in National Road Schemes’[10]. These Guidelines are based around an absolute noise level as a design goal, and the review showed that noise barriers were sometimes being used in potentially unsustainable ways to achieve this goal.

5 THE FUTURE

It is clear that present noise assessment procedures are recognizably the same as 40 years ago, but study areas have become much larger and more scenarios need to be considered. The proliferation of noise indexes and assessment tables has not led to better evaluation or understanding of noise impact, and there is inadequate guidance on how the plethora of information should be interpreted.

It is possible that one reason for the stagnation of noise impact assessment has been the difficulty of presenting results quickly and clearly. However, this paper shows that a new generation of noise assessment tools is available.

This gives a new generation of researchers the opportunity to take advantage of new tools and to apply them to improving this much-neglected area of work.

FIGURES

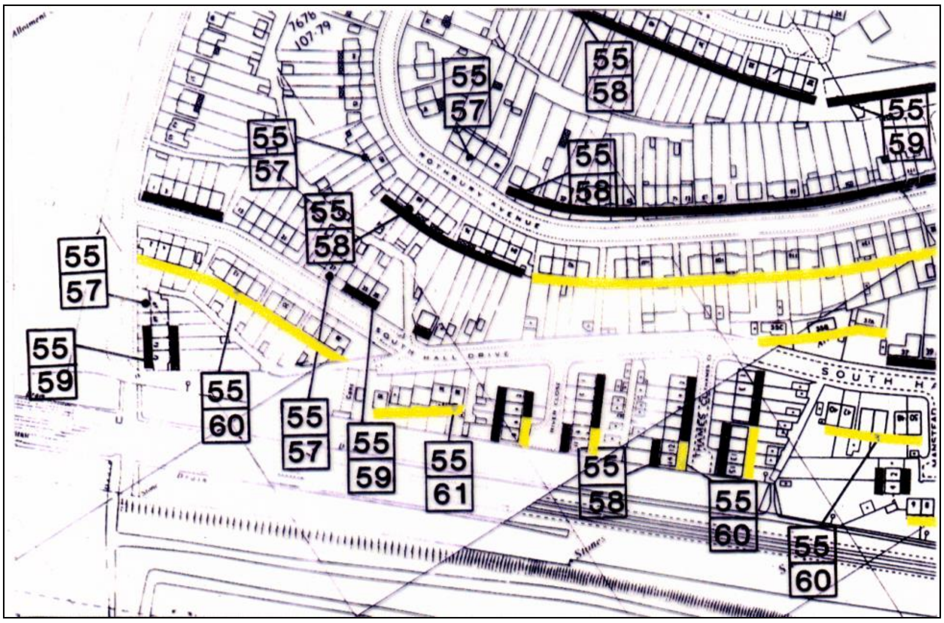

Figure 1 – Part of Hand-drawn Noise Map, 1989

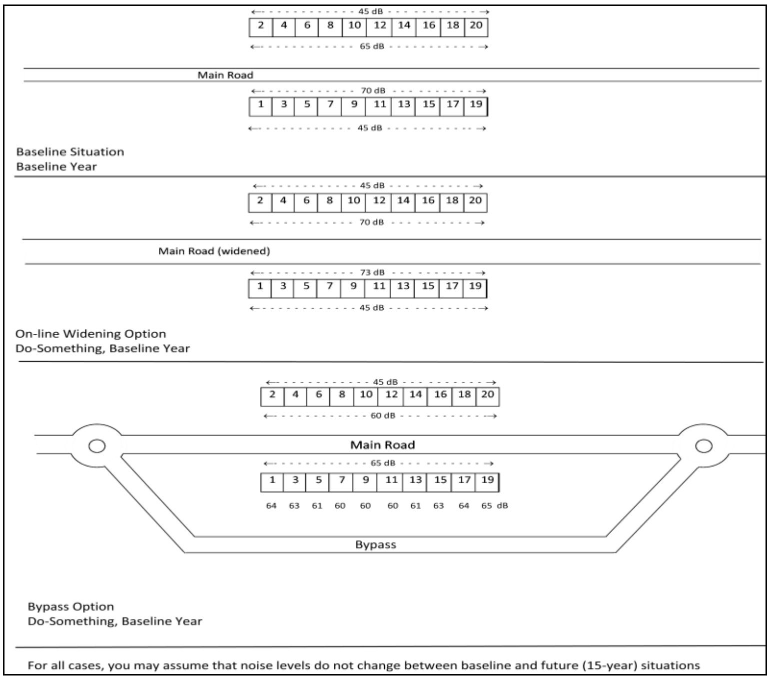

Figure 2 – Assignment for Students to assess noise impact

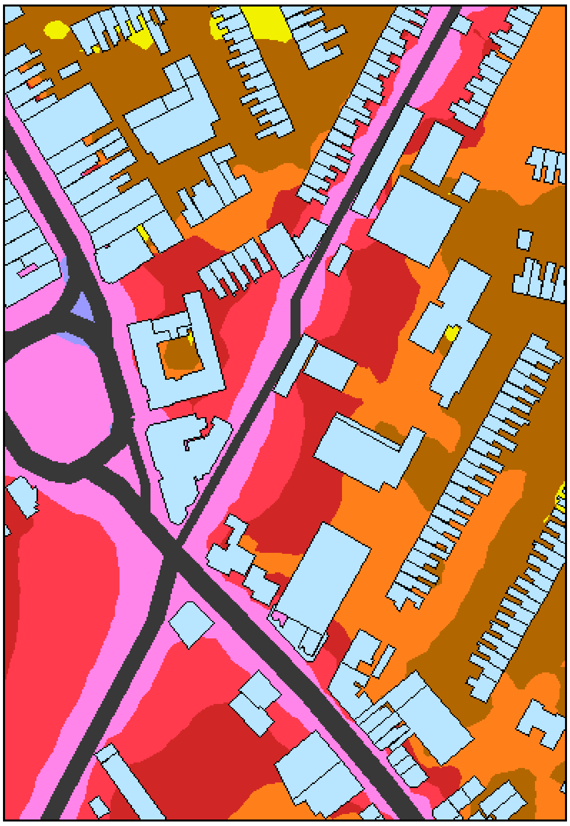

Figure 3 – Noise contours overlaid on map

Figure 4 – Noise levels applied to buildings

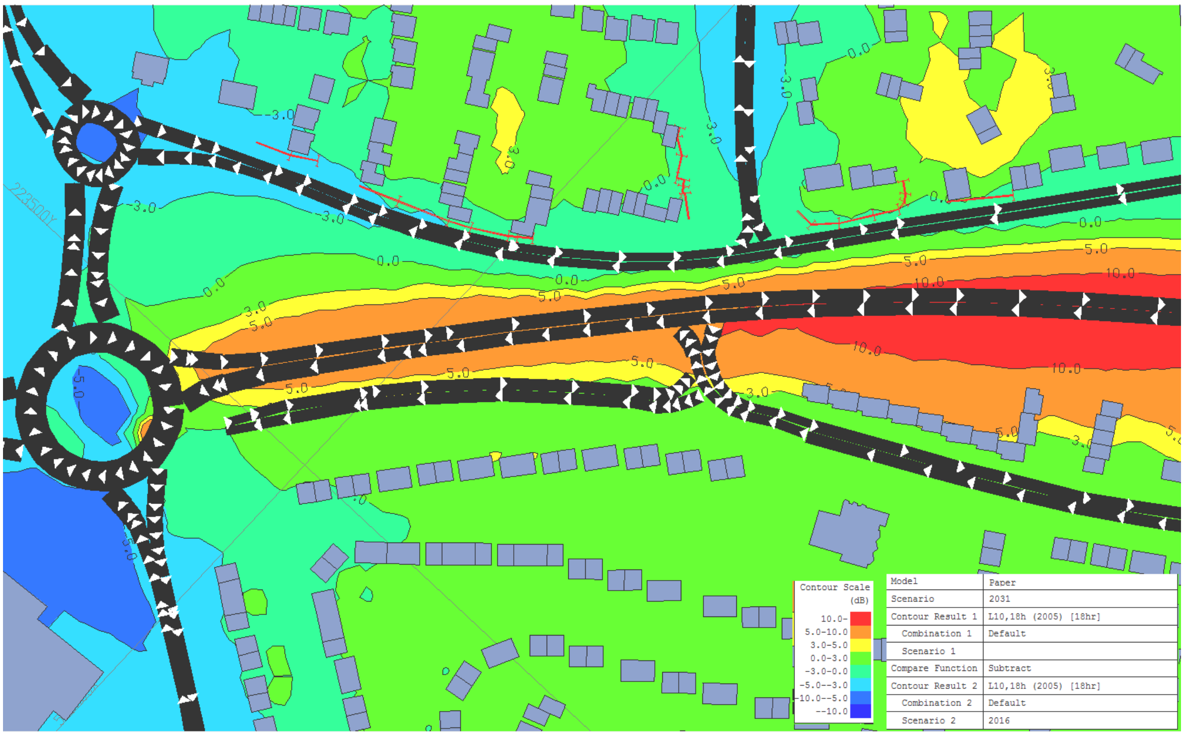

Figure 5 Noise Map showing change of noise levels on part of larger scheme

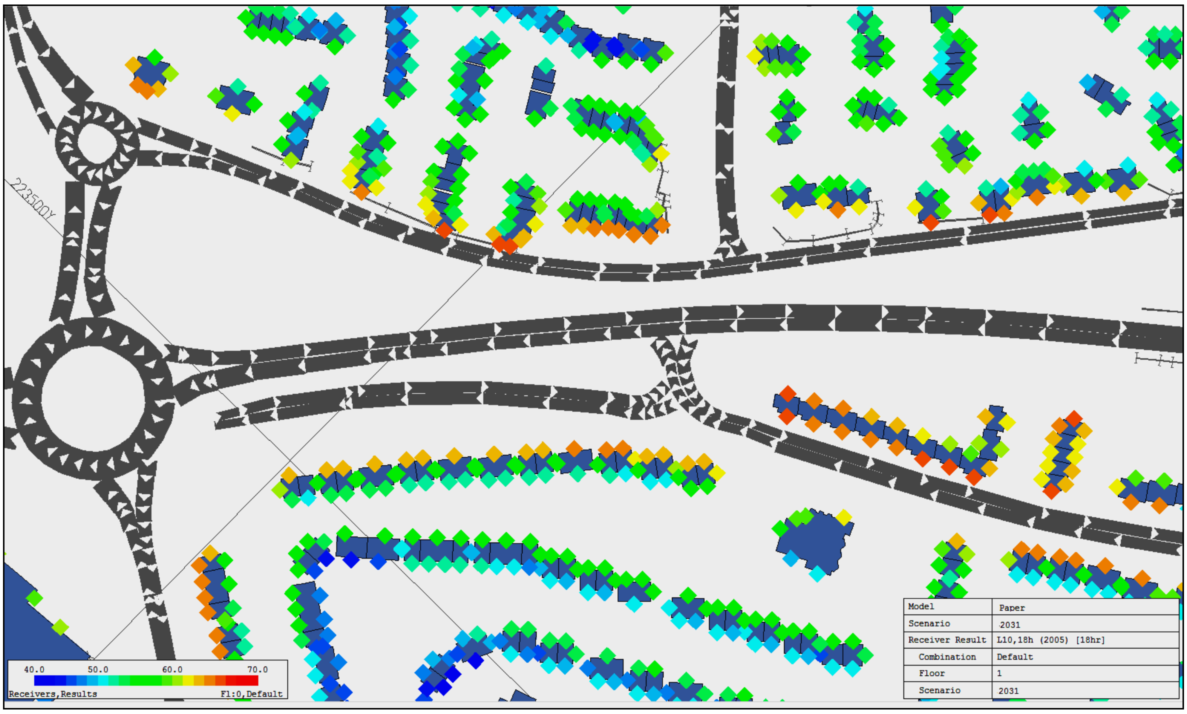

Figure 6 Noise Map showing Receiver Noise Levels on same part of scheme

Table 1 - Short-term Change in Traffic Noise Levels within Study Area			
Change in Noise Level Do-minimum v Scheme in opening year		**Number of Dwellings**	**Number of other receptors**
Increase in Noise Level, $L_{A10,18hr}$	0.1 - 0.9	926	
	1.0 - 2.9	3949	2 schools
	3.0 - 4.9	53	
	5 +	17	
No Change	0	79	
Decrease in Noise Level, $L_{A10,18hr}$	0.1 - 0.9	728	
	1.0 - 2.9	957	
	3.0 - 4.9	1182	
	5 +	1707	

Table 2 - Long-term Change in Traffic Noise Levels within Study Area				
		Daytime		**Night-time***
Change in Noise Level Do-minimum in Baseline year v Scheme in design year		**Number of Properties**	**Number of other sensitive receptors**	**Number of dwellings**
Increase in Noise Level, $L_{A10,18hr}$	0.1 - 2.9	5087	2 schools	-
	3.0 - 4.9	267	-	-
	5.0 - 9.9	30	-	-
	10 +	1	-	1
No Change	0	94	-	-
Decrease in Noise Level, $L_{A10,18hr}$	0.1 - 2.9	1533	-	-
	3.0 - 4.9	964	-	11
	5.0 - 9.9	1463	-	-
	10 +	159	-	-

Table 3 - Change in Traffic Noise Nuisance within Study Area

Between Baseline year and Design Year		Do-Minimum Number of Dwellings	Do-Something Number of Dwellings
Increase in Nuisance Level	< 10 %	9504	420
	10 < 20 %	0	506
	20 < 30 %	0	3114
	30 < 40 %	0	890
	> 40 %	0	15
No Change	0	94	79
Decrease in Nuisance Level	< 10 %	0	4574
	10 < 20 %	0	0
	20 < 30 %	0	0
	30 < 40 %	0	0
	> 40 %	0	0

Table 4 - Number of people bothered by noise

Total dwellings	Do minimum Baseline Year	Do something Baseline Year	Do something Future Year
9598	**1552**	**1589**	**1682**

6 REFERENCES

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10. Guidelines for the Treatment of Noise and Vibration in National Road Schemes. October 2004. National Roads Authority, Ireland.