EURONOISE 2006
30 May - 1 June 2006 Tampere, Finland

USER CONTROLLED SETTINGS IN NOISE MAPPING SOFTWARE – THE EFFECTS ON CALCULATION SPEED AND ACCURACY.

Peter Hepworth[1], James Trow[2], and Vincent Hii[3]

[1]Hepworth Acoustics Limited
5 Bankside, WA1 1UP, Warrington, England

peter.hepworth@hepworth-acoustics.co.uk
james.trow@hepworth-acoustics.co.uk
vincent.hii@hepworth-acoustics.co.uk

ABSTRACT

Noise mapping is an increasingly important method of assessing environmental noise. Noise maps are being generated for projects ranging from small scale new developments with a single noise source to large agglomerations with many noise sources. The largest noise maps require millions of calculations to be carried out and this can lead to long processing times and significant costs for hardware and software. In order to reduce calculation time, noise mapping packages offer efficiency settings which reduce the complexity and numbers of calculations required. Questions over the impact on accuracy and uncertainty of using these efficiency techniques continue to be posed and little objective data has been published about the correlation between calculation speed and accuracy. In addition, the accuracy required from noise maps varies depending on the end use of the data. A noise map required to assess eligibility under the Noise Insulation Regulations for a new road where noise levels are reported to the nearest 0.1 dB will have different requirements to a city wide noise map.

These concerns prompted the Department for Environment, Food and Rural Affairs (Defra) to commission research in 2005 on the effect of efficiency techniques on the accuracy of noise levels calculated by mapping software using the United Kingdom road traffic noise prediction methodology – Calculation of Road Traffic Noise (CRTN). Two papers are presented to detail some of the findings from this research.

This, the second of the two papers identifies calculation settings available in five noise mapping packages which act as efficiency settings. The research found that for one noise mapping package, effective use of efficiency settings made it possible to reduce calculation time by 99% for an error of 1.09 dB(A).

1 INTRODUCTION

In support of Defra's Noise Research Advisory Service (NRAS) contract, a research project was commissioned to investigate the impact of various efficiency settings found in five commercially available noise mapping software, upon both the computation time and accuracy of large scale environmental noise calculations. Defra has responsibility for a wide range of noise issues in England. This includes providing guidance on the methodology to be used for assessing the noise impact of new developments through to implementing the European Noise Directive (END). The project was commissioned specifically to inform Defra of the impact of efficiency settings in terms of speed of calculation and accuracy of results. The project was restricted to assessing CRTN [1] and therefore the results presented in this and the related paper will not be directly applicable to implementations of other calculation standards within the software.

This paper utilizes the benchmark results obtained in the first paper [2] to assess the impact of various efficiency settings provided in the different software. The aim of this work is to quantify the impact of efficiency techniques both in terms of the cost incurred on accuracy and any potential benefit in speed of calculation. The paper provides examples of efficiency settings that perform poorly in terms of accuracy when carrying out road noise calculations in accordance with CRTN, as well as those that perform well.

In Paper 1 [2], benchmark settings were detailed to provide the highest level of accuracy for CRTN compliant calculations achievable from each package. However, it was concluded that it is impractical to use the benchmark settings for noise mapping calculations due to the length of calculation times. The paper concluded that efficiency settings should be used in noise mapping work. It is clear, however, that their use must be informed and controlled.

From the research detailed in [4], [5], [6], it is clear that software developers have recognised potential concerns regarding calculation times and have subsequently developed methods of speeding up calculations. A literature review showed that software developers have incorporated different methods to improve the calculation speed. Efficiency techniques are one of them [6]. Other methods to improve calculation speed include reducing the resolution of modeling data through geometrical simplification [3] and calculation distribution models which allow calculations to be spread across a greater number of hardware platforms [5].

This current study is similar to Kang and Huang's [3] and Rudno-Rudzinska and Habrat's [4] work which involved examining the efficiency and accuracy of results obtained from some 3D model simplification and some calculation configuration. In [3], the software calculated results have been validated against benchmark results which were obtained using the image source method. Although in the current study, the benchmark results are obtained via a different manner, the focus of the work is similar. This study aims to extend understanding in this area through a systematic investigation of five of the leading commercial noise mapping software.

Efficiency settings can increase the basic speed of calculation but usually introduce a compromise in terms of accuracy. The literature review found that there is little objective information on the level of error introduced and the benefit gained due to applying efficiency techniques. This research aims to investigate some of the efficiency techniques provided in the various noise mapping packages and to quantify their effect on the accuracy of the calculated noise levels and speed of calculations.

Part of the study was to see what combination of efficiency settings in each software could be used such that the accuracy of the results, in average, was affected by around ± 1 dB(A) i.e. (2 dB(A) 95% Confidence Interval).

2 METHODOLOGY

This study was carried out in five stages. Stage 1 was the identification of calculation settings in different noise mapping software which relate to efficiency techniques and have an impact on accuracy. This stage was reported in [3] and included obtaining benchmark calculation times when no efficiency settings were applied.

Stage 2 was the design of a test matrix which detailed the efficiency settings to be investigated and the range of parameters to be assessed for the five different packages. Initially, efficiency settings were tested in isolation so that the effect of each setting could be quantified alone. This information enabled the effect of combined settings to be predicted at a later stage of the study. All settings, other than the setting being tested, were configured to benchmark parameters. Due to the variation in calculation times and the time restrictions for the project, different numbers of calculation points were used for the different software. Table 1 shows an example test matrix of parameters tested for one software package. Table 2 shows the number of efficiency settings investigated in each of the noise mapping software and the number of calculation points assessed. The software investigated are denoted by letters A to E.

Table 1: Example Test Matrix

Index	**Efficiency Setting**	**Parameters**				
1	Source Search Radius	2000m	1000m	500m		
2	Dynamic Error Margin	0 dB	0.5 dB	1.0 dB	3.0 dB	5.0 dB
3	Minimum Section Length	0.01	0.05	0.10	0.25	0.50
4	Contour Line Utilisation	500m	250m	100m	50m	25m
5	Reflection Radius	50m	30m	10m		
6	Simplification of Propagation	Off	On			
7	Grid Interpolation under Ambient	Off	On			
Variant		**BM**	A	B	C	D

Table 2: Number of Efficiency Settings investigated and calculation points in each noise mapping package

Software	**A**	**B**	**C**	**D**	**E**
No. of Settings Investigated	7	6	4	11	4
No. of Calculation Points Assessed	10,000	40	9,050	40	1,200

Stage 3 was the quantification of the calculation time for each test and the associated error introduced by the value used for the efficiency setting. Calculation times were obtained from outputs created by each of the software. To ensure consistency, identical hardware environments were used for all software and are identical to those used to obtain the benchmark calculation times in [3].

Accuracy has been assessed by using the benchmark results obtained in [3]. A program was developed in FORTRAN to specifically perform statistical analysis by comparing the benchmark results with the results obtained from each of the tests in the matrices. Traditional statistical measures such as standard deviation and 95% confidence interval have been used as a measure of error. The maximum change and range of error was also considered. A percentage reduction in calculation time from the benchmark has been used as a measure of change in calculation time.

Stage 4 was an assessment of the results obtained from the testing of individual settings, followed by the recommendation of settings for parameters to be considered for simultaneous assessment. Recommendations were made by considering both the calculation time reduction and the error introduced. A simple mathematical operation was performed to predict the overall error from the combination of a number of efficiency settings.

Stage 5 was the testing and documentation of the final recommended calculation settings. This required all of the settings chosen in stage 4 to be used in a calculation to ensure that the interaction of different efficiency settings did not increase the overall error above the prediction.

3 RESULTS

The research not only identified efficiency techniques that perform well by reducing calculation times significantly without introducing unacceptable error, but has also identified some efficiency techniques that introduce high levels of error, sometimes without significant reductions in calculation times. Table 3 presents a summary of the settings and values that introduced large errors or made little difference to the calculation time. The magnitude of some of the errors introduced by some efficiency settings reinforces the importance of making informed judgments about the use of these settings to speed up noise mapping calculations.

Table 3: Summary of poor performing settings

Software	**Setting**	**BM**	**TC**	**Reduction in calculation time w.r.t. benchmark time**	**Error w.r.t. benchmark results (95% Confidence Interval) (dB)**
A	Source Search Radius (m)	2000	500	97.4%	4.20 dB
	Minimum Section Length	0.01	0.50	-0.85%	1.86 dB
	Reflection Radius	50m	10m	-0.32%	1.06 dB
B	Maximum Level Difference	Rigid	10 dB	99.2%	2.04 dB
D	Source Search Radius (m)	2000	500	92.9%	3.75 dB
	Maximum Error	0 dB	5 dB	91.5%	4.51 dB

E	Angle Increment (degrees)	1°	5°	90.2%	4.56 dB
	Reflection Radius	50m	10m	0.36%	1.37dB

It is important to remember that the statement of error in table 3 is the 95% confidence interval. The range of error for these settings was identified as being high, in some cases >10 dB(A) from the benchmark results. In table 3, a negative reduction in calculation time relates to a calculation time longer than the benchmark settings.

Table 4 presents a summary of the efficiency settings and their parameters identified in the software which provide good performance in terms of reducing calculation time and maintaining a good level accuracy. No results appear in tables 3 or 4 for one of the software. This is because the results showed increasing calculation times with the application of efficiency settings. Therefore in the case of this particular software, the recommended settings were kept the same as the benchmark settings.

Table 4: Summary of Recommended Settings

Software	Setting	BM	TC	Reduction in calculation time w.r.t. benchmark time	Error w.r.t. benchmark results (95% Confidence Interval) (dB)
A	Dynamic Error Margin	0dB	3dB	82%	0.35 dB
	Simplify Propagation Analysis	Off	On	21%	0.04 dB
	Simultaneous Testing			**88%**	**0.35 dB**
B	Projection of Line Sources	Rigid	Off	96%	1.07 dB
	Maximum Difference Level	Rigid	30dB	84%	0.21 dB
	Minimum Section Length	Rigid	0.5m	39%	0.06 dB
	Simultaneous Testing			**99%**	**1.09 dB**
D	Maximum Error	0dB	1dB	66%	0.16 dB
	Projection of Line Sources	On	Off	83%	0.42 dB
	Projection of Terrain Model	On	Off	35%	0.03 dB
	Minimum Length of Section	0.01m	1m	51%	0.03 dB
	Simultaneous Testing			**94%**	**0.45 dB**
E	Angle Increment	1°	2°	54%	1.46 dB
	Ground Sample Points	20	4	29%	0.04 dB
	Simultaneous Testing			**54%**	**1.49 dB**

4 DISCUSSION

Investigation of the five noise mapping software in this research and their respective efficiency settings has led to the conclusion that the software are unique in terms of the settings they offer. The study found only one setting (source search radius) which is common across the five packages.

Although the software offer settings which effectively control identical parts of the calculation method, the way in which they are defined can not always be compared directly with the other software. The same applies for the implementation of the setting during calculation. Although comparable settings have similar objectives and functions, the method of implementation is usually different between software.

The results in section 3 show that efficiency settings can significantly reduce the calculation time and the accuracy of calculated noise levels. The results also show that some efficiency settings perform significantly better than others, i.e. greater reduction in calculation time for less error. It can be argued that some parameters do not act as efficiency settings and should actually be viewed as user defined accuracy settings or settings which allow the user to have control over the decisions made by the software. Examples are the reflection search and source search settings.

The results in table 3 provide objective information on the accuracy implications of some of the worst performing settings. Table 3 shows that although some settings give large reductions in calculation time, the error introduced as a cost can be unacceptably high. It is also important to remember that the results in table 3 are from testing of that parameter setting alone. There may be cases where a user applies many settings simultaneously, leading to larger compound errors.

In general, as expected, moving away from the benchmark settings resulted in decreasing calculation time with error being introduced. A significant range of time reductions was identified. Some test cases resulted in little or no reduction in calculation time, whereas some cases resulted in calculation times reducing by 98%.

Settings such as error margins and maximum level differences work as effective tools for reducing calculation time with an acceptable level of error being introduced. Current investigations have shown that there are optimum values of these parameters in terms of a cost benefit relationship. Misuse or misunderstanding of these parameters can introduce significant errors and therefore a cautionary approach should be adopted in their usage.

Some results were identified where an efficiency technique performed differently in different packages. For the minimum section length, in software A moving away from the benchmark setting showed no significant pattern in the reduction of calculation time although errors were introduced. However, in software B and D the minimum section length setting could reduce calculation time with a negligible impact on accuracy over the range of values investigated.

When comparing the results in tables 3 and 4, the research has shown that large reductions in calculation time can be achieved by various efficiency techniques, but very different levels of error are introduced. Information has been provided for the best performing efficiency techniques when carrying out CRTN calculations. There are still significant differences in calculation speeds between the different software when the recommended efficiency techniques are applied.

As these results have been obtained from calculations using the CRTN methodology, the settings discussed may not be appropriate for use with other calculation standards, although some of the general findings may be relevant. It is recommended that further research should be implemented to obtain recommended settings for other noise calculation standards implemented in the noise mapping packages.

5 CONCLUSION

A research project has been carried out to investigate the efficiency settings and parameters available in five commercial noise mapping software packages. The effect of using the "efficiency" settings has been investigated by comparing the time taken and results generated when utilising these settings compared to results obtained from "benchmark" settings for each software.

The results of this research have shown that considerable reductions in calculation time can be achieved by utilising some efficiency settings available within noise mapping software. The effect of efficiency techniques on the accuracy of results is very variable, some techniques will introduce considerable errors whereas others will introduce a very low level of error. There is no direct correlation between the reduction in calculation time and the level of error introduced.

In conclusion, the use of efficiency techniques is considered to be essential in carrying out noise mapping within reasonable cost and timescale parameters. However, it is vital that the users of the mapping software understand the implications of the application of the different efficiency techniques and make an informed decision on the techniques to be used in the light of criteria that have been adopted on the acceptable level of error for the calculations. The effects of the efficiency techniques are likely to vary with different calculation methodologies, and therefore decisions should be made on the basis of standard specific testing. Finally, the development of noise mapping software is a dynamic process, and updates and changes to the software may well impact on the effect of the efficiency techniques. Decisions on the use of efficiency techniques should therefore be based on the relevant version of the software being used.

REFERENCES

[1] Calculation of Road Traffic Noise, Department of Transport, HMSO, 1988

[2] Reference Settings in Noise Mapping Software – A Comparison of the Speed of Calculation for Different Software. Hepworth, P. Trow, J. and Hii, V. Euronoise 2006, 30th May – 1st June 2006, Tampere, Finland.

[3] Noise mapping: Accuracy and strategic application. Inter-noise 2005 – Environmental Noise Control. Kang, J. and Huang, J. 7th – 10th August 2005, Rio de Janeiro, Brazil.

[4] Influence of Calculation Parameters on Time and Accuracy of City Road Noise Computations. Rudno-Rudzinska, B. and Habrat, T. Forum Acusticum 2005, Budapest, Hungary.

[5] Strategic Mapping of Noise and Air Pollution. Probst, W. and Metzen, H. Forum Acusticum 2005, Budapest, Hungary.

[6] Optimising Uncertainty and Calculation Time. Stapelfeldt, H. and Manvell, D. Forum Acusticum 2005, Budapest, Hungary.