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REFERENCE SETTINGS IN NOISE MAPPING SOFTWARE – A COMPARISON OF THE SPEED OF CALCULATION FOR DIFFERENT SOFTWARE

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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 first of two papers identifies the most accurate and compliant settings (benchmark settings) for performing CRTN calculations in five different noise mapping packages. Calculation times using benchmark settings ranged from 11.4 seconds to approximately 4,400 seconds per calculation point depending upon the noise mapping software used.

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.

The results of this research are presented in two papers. This paper sets out to identify calculation settings that offer the highest accuracy of calculation achievable from the software packages for the CRTN methodology. These settings are referred to as benchmark settings. This paper assesses the practicality of using benchmark settings for noise mapping. The second paper [2] discusses the impact that various efficiency settings have on calculation speed and accuracy.

A literature review found little objective discussion regarding the calculation time of different noise mapping software [3]-[10]. A study of the software manuals also found very little information regarding the accuracy implications of efficiency settings, although they did identify options for reducing calculation time.

2 METHODOLOGY

The work presented in this paper has been carried out in two main stages. Stage 1 is the identification of calculation settings available in different noise mapping software and their most accurate values in order to obtain benchmark settings. Stage 2 is the identification of calculation speed per calculation point using the benchmark settings for each software package with an identical test model and hardware environment.

2.1 CALCULATION SETTINGS

Due to the nature of the research it was imperative to identify and understand the function of calculation settings available in each of the noise mapping packages investigated. The main focus was placed on efficiency settings. These were defined as calculation settings which have the purpose of reducing calculation time at an accuracy cost and settings which effect accuracy and which may have a subsequent effect on calculation time. This was achieved by using software manuals, supporting literature, online help files and where necessary, clarification from the software developers [6], [8], [9], [10].

This research identified a series of different techniques developers employ in order to reduce calculation time and the different ways they are presented to the user. Research identified calculation settings which are similar across different packages both in terms of function and definition e.g. Source Search Radius. In these cases, the benchmark setting has been replicated across all software for consistency. In some cases, packages offer settings which are similar in nature to others but different in terms of the user input and how the setting should be defined. Some packages offer settings which are unique and cannot be found in other packages.

In general, efficiency settings fall into two types: those which require the user to define a value or parameter which the software will adopt during the calculation (e.g. source search radius); and simple switches which the user can activate or deactivate. In both cases, the efficiency setting relies heavily upon the user's knowledge of the software, the calculation standard and experience with noise calculations in general. In most cases, little or no guidance is provided by the developers, in online help or manuals, regarding the potential accuracy implications of the settings. Most emphasis in the text is placed on the benefits of reducing calculation time.

Some packages employ some efficiency settings which allow the user to specify an indication of the accuracy or error which they will accept in the calculation. These settings usually work by neglecting sources which the software determines as having an effect on the overall level at the calculation point by a margin smaller than the error set by the user or by simplifying paths of propagation based on the developer's own criteria. Although these settings may offer the user an element of control, they are not isolated from other calculation settings and therefore the actual total error in the calculations may be larger than the user specifies due to the effect of other efficiency settings. In order to remove any software controlled sources of error from the benchmark calculations, error margins, tolerances and simplification features were turned off.

Some calculation settings within the software are critical to achieve compliance with the calculation standard. If these are set to inappropriate values or deactivated, specific parts of the calculation standard may be neglected or the calculations may deviate away from the original standard. An example of this is the treatment of reflections where both objects and calculation settings must be configured correctly or reflections may not be taken into account or may be subject to a deviation from the calculation standard.

The benchmark results are obtained by excluding completely the use of efficiency settings or, where necessary, having the efficiency setting parameters set to minimise their effect as much as possible. It is recognised by the authors that the software developers do not recommend using the settings adopted as benchmark settings for the purposes of noise mapping. However further investigation into the accuracy implications of efficiency settings [2], requires a benchmark of the most accurate noise levels generated by the software to ensure a true representation of any error introduced.

Table 1 presents calculation settings identified to have an effect on calculation time or accuracy of calculated noise levels. The table shows the availability of the settings across the five noise mapping packages for calculations according to CRTN. The five software are identified by letters A to E. The benchmark parameter adopted is also displayed for the different calculation settings. It is important to note that all interpolation features were deactivated.

Table 1. Efficiency Settings availible in different software and benchmark settings

Setting	**Noise Mapping Software**				
	A	**B**	**C**	**D**	**E**
Source Search Radius (m)	2000m	RIGID	2000m	2000m	2000m
Maximum Distance Source – Receiver (m)	-	-	-	2000m	-
Reflection Radius (m)	50m	50m	-	50m	50m
Reflection Depth	-	-	0	-	-
Maximum Level Difference (dB)	-	RIGID	-	-	-
Dynamic Error Margin (dB)	0 dB	-	-	-	-
Maximum Error (dB)	-	-	-	0 dB	-
Tolerance (dB)			0 dB		
Minimum Section Length (m)	-	RIGID	-	0.01m	-
Minimum Section Length (%)	1%	-	-	1%	-
Angle Increment (degrees)	-	RIGID	1^{o}	-	1^{o}
Projection of Line Sources	-	On	-	On	-
Simplify Propagation Analysis	Off	-	-	-	-
Projection of Terrain Model	-	-	-	On	-
Ground Model Sample Points	-	-	-	-	20
Interpolation of Results	ALL INTERPOLATION FEATURES DEACTIVATED				

- Denotes setting not available for calculations according to CRTN within Noise Mapping Package

2.2 TEST MODEL

A test model was created using Central Data Service (CDS) data as supplied to contactors working on Defra's Noise Mapping England (NME) project. A $25km^2$ sample was extracted from the Liverpool / Birkenhead data region as shown in Figure 1. The test model was chosen as it contains all relevant geographical features and propagation scenarios to evaluate the computational load required by each software package and to ensure that all parts of the calculation standard are tested. Within the test model, a 1x1 km calculation area is defined to allow for a 2km data buffer.

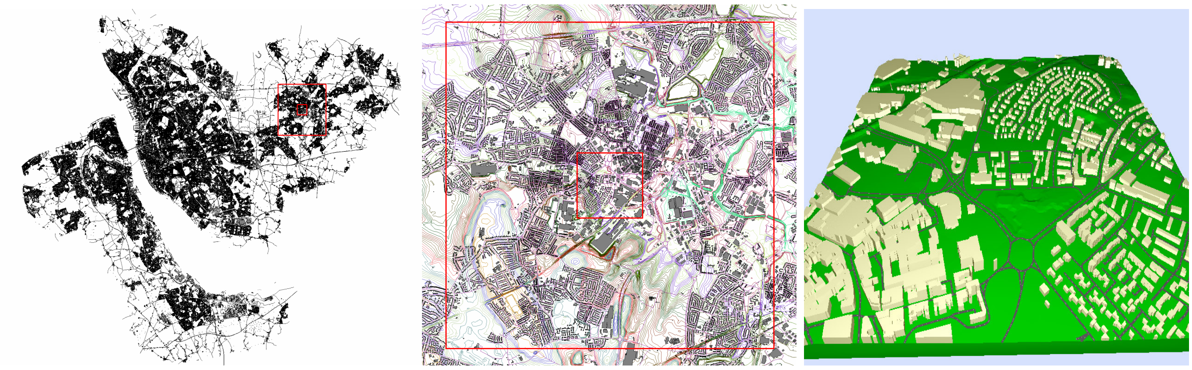

Fig.1. (a) Location of test area. (b) Zoomed in test area. (c) 3D view of the test area.

The CDS data was very detailed. It was acknowledged that contractors working on the NME project would not be using CDS data without some level of simplification. For consistency, a simplified version of the model data was generated in GIS, although the simplified version still contained all of the necessary detail. As the simplification was done externally, the test model was exported to shape files and then imported into the software. Further steps were then taken to make sure the models were configured correctly. This included the configuration of sources to ensure consistent noise emission levels and road widths.

2.3 PRELIMINARY INVESTIGATIONS

Before detailed testing was carried out, a series of low to medium resolution grid calculations was carried out using the benchmark setting in the software for the 1km^2 calculation area. Based on calculation times obtained from these initial tests, a calculation time for the full 10m grid was predicted by extrapolation. This procedure was implemented to ensure that the benchmark calculations could be carried out within a reasonable time scale and hence allow a series of subsequent tests to be carried out.

Table 2 presents extrapolated calculation times for software B, D and E at 10m grid resolution. For software A and C, a full calculation at benchmark settings was found to be possible within three days and therefore actual calculation times are presented.

Table 2: Extrapolated or/Actual calculation times at 10m grid resolution for the 1km^2 calculation area.

Software	**A(*)**	**B**	**C(*)**	**D**	**E**
Extrapolated/Actual Calculation Time (days)	1.3 days	60 days	1.54 Days	277 days	7.9 days
Time per calculation point (seconds)	11.2	518.4	13.3	2393.3	68.3

** A full calculation at benchmark settings was performed.*

It can be seen in table 2 that the calculation time per point varies significantly between software. Calculation times range between 11.23 to 2393.28 seconds. Due to project timescales, a 10m grid calculation was not feasible for B, D and E for the main calculations. As a result, alternative methods of assessment were devised for these software.

2.4 ASSESSMENT OF PRELIMINARY RESULTS

The results presented in table 2 show that within a three day period, only software A and C were capable of completing the calculation at 10m grid resolution.

For software B, D and E, alternative assessment methods were therefore considered to enable the calculation at benchmark settings to be completed within 3 days. In order to reduce the calculation time required for the benchmark calculations but to maintain accuracy in the calculated level the assessment method developed focused on reducing the number of calculation points. Software E was found to be capable of calculating 1200 calculation points in around 24 hours. A stripe of 1200 receiver points at 10m spacing was defined across the model taking into account several acoustic scenarios, such as free propagation and high levels of screening. Software B and D were found to be capable of approximately 300 and 75 grid calculation points in 48 hours respectively. Initial work had identified that both software B and D took significantly longer to perform receiver point calculations than grid calculations. The course of action taken was to use 40 receiver points for both software B and D located in identical geometrical locations as those in the original 10m receiver grid.

The locations of the 40 receptor points were determined by creating five zones within the 1km^2 calculation area, each representing different land usages and propagation scenarios. In each zone, eight calculation points were randomly selected. The receiver points were defined such that none of them fell within buildings.

3 RESULTS

Table 3 presents a summary of the calculation time taken for the five software tools and the calculation time per point.

Table 3. Benchmark calculation times for different software.

Software	**A**	**B(*)**	**C**	**D(*)**	**E**
Total Calculation Time (hours)	31.7	48.7	36.9	39.9	25.7
Number of Calculation Points	10000	40	9050	40	1200
Calculation time per Point (seconds)	11.4	4383.0	14.7	3600.0	77.0

** Point calculations carried out rather than grid calculations*

4 CONCLUSIONS

The results presented in this paper have identified calculation settings which offer the highest accuracy for CRTN compliant calculations made in each noise mapping package investigated. The results shows that at benchmark settings a wide range of calculation times is produced, ranging from 11.4 seconds per grid point up to around 4,400 seconds (1.22 hours) per calculation point. These results indicate that the calculation times are longer than desirable, even for small numbers of calculation points. It is certainly not feasible to perform large scale noise mapping calculations using benchmark settings. The use of parallel computing can reduce calculation times, but this also increases costs due to the need for additional software licenses and hardware. Therefore the use of efficiency settings in noise mapping is essential if results are to be delivered within reasonable timescales.

The results of the study into the effect of efficiency techniques on calculation speed and accuracy are presented in the second paper [2].

REFERENCES

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

[2] User Controlled Settings in Noise Mapping Software – The Effects on Calculation Speed and Accuracy. Hepworth, P. Trow, J. and Hii, V. Euronoise 2006, 30th May – 1st June 2006, Tampere, Finland.

[3] Implementing Prediction Standards In Calculation Software – The Various Sources Of Uncertainty, (2005), Erwin. H.V.B and Stapelfeldt, H. Managing Uncertainty In Noise Measurement and Prediction – Symposium Le Mans (France) 27-29 June 2005

[4] Implementation of The EU-directive on environmental noise – Requirements for calculation software and handling within CadnaA. Probst,W. Munich, May 16th 2003.

[5] NORDTEST Method, NT ACOU 107 Approved 2001-2005. ISSN 0283-7145. Project 1455-99.

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

[7] Assessment of data sources and available modelling techniques – are they good enough for comprehensive coverage by computer noise mapping. Carruthers, D., Stocker, J. and Oates, Bill. Report by Cambridge Environmental Research Consultants Ltd.

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

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

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