Edinburgh, Scotland
EURONOISE 2009
October 26-28

Illustration of QA measures for noise mapping software

Klaus-Georg Krapf[a]
Edgar Wetzel[b]
Wölfel Meßsysteme · Software GmbH+Co.KG
Max-Planck-Str. 15
97204 Höchberg/Germany

ABSTRACT

After the first round of EU strategic noise mapping is finished and action plans based on these noise maps are being developed, it becomes clear that the approaches taken to ensure the quality of calculated results do differ between Member States. In Germany comparison with measurement is precluded and test case calculations are the preferred way. However, in other Member States the comparison with measured data is mandatory. Furthermore, statistical approaches to ensure quality of calculations have been developed and are in the process of standardisation. The present paper illustrates specific aspects of QA in noise mapping on the basis of the experience gained in past projects.

1. INTRODUCTION

The END and the concept of large-scale strategic noise mapping introduced a new level of size and dimension into noise mapping. Considering the inherent uncertainties of calculation methods and input data, ensuring the overall quality of a large-scale noise map becomes a challenge. Even though both quality of input data and understanding of calculation method and mapping software remain the anchor stones of high-quality noise mapping, the sheer size of modern noise maps requires computer-aided statistical methods to assess the overall quality.

The first round of strategic noise mapping is finished and the second round will be starting soon. Experience from the first round of mapping can be used to improve the process and the quality of the output for the second round. Several aspects of quality assurance in noise mapping were studied by the authors in the realm of noise mapping software projects. The following four-tier approach was used in several strategic noise mapping projects and will be discussed in this paper:

- Understanding of the calculation method: Studying the sensitivity of the different equations of a calculation method provides a better understanding of the calculation method itself and guides the user in targeting his data improvement efforts.
- Quality assurance of input data: It is well known that the accuracy and overall quality of the input data has a major impact on the calculated results. This is as true for noise mapping as it is for any other calculation. For discussions of quality assurance and error propagation on GIS, please refer to [3], [6], [7], and [8].
- Statistical analysis of the influence of efficiency settings on the relative accuracy of the calculated results using DIN 45867.
- Comparison with measured noise pressure levels to determine absolute accuracy.

[a] krapf@woelfel.de
[b] wetzel@woelfel.de

2. A FOUR-TIER APPROACH TO QA

A. Understanding the Sensitivity of the Calculation Method

A thorough understanding of the calculation method of choice is a base requirement to produce quality noise maps of any size. A noise propagation calculation method is a collection of equations. Each effect on the propagation path is calculated individually (sometimes including some interference with another effect – e.g. interaction between screening and ground effect). The individual effects are generally summed up arithmetically to yield the final noise level at the receiver point.

Typically the result of a calculation is not influenced to the same degree by all effects taken into account. Some have a bigger and others a smaller impact on the final result. The calculation of each single effect only uses part of the total data available: understanding the sensitivity and its link with input data helps identifying the data that are most decisive in determining the final result. Understanding the sensitivity of the calculation methods helps on the one hand to better understand calculated results and on the other hand to devise suitable tactics to improve the input data by means of concentrating first on those parts of the data that are most probable to have a big effect.

B. Quality Assurance of Input Data

The better part of all input data for large-scale noise mapping projects is imported from existing datasets. The advantage is the almost immediate availability of the data. The disadvantages are the uncertainty of the timeliness of the data, the need to correlate datasets from different sources answering different needs and therefore submit to different accuracy requirements and update cycles. Lacking data must be compensated either by self-procurement of data or by using substitutes. The latter remain a notorious source of uncertainty. Aspects that should be checked include (but are not limited to):

- First things first: Is the data fit for the purpose of noise mapping? The availability of data says nothing about its suitability for noise mapping. This is a first check that must be made. For instance: building data are available in abundant quantity but often lack real z-coordinates. Terrain level data are available with high spatial accuracy but do not necessarily describe the edges in terrain that act as barriers to sound propagation.
- Completeness of data: are all data available? Notorious candidates for lacking data are purpose build sound barriers and road surface layers or ballast types. Z-coordinates are not always available and come in different forms, which may require a further step of calculation prior to using them. Acoustics attributes are rarely readily available.
- Geo-referenced data can be compared with recent aerial photographs if it can be reasonably assumed that these photographs are more recent than the original GIS data. This comparison would help identify lacking elements in data layers (such as buildings either recently constructed or recently demolished).
- If datasets from different sources must be merged, it is recommended to check whether they are compliant with the chosen coordinate system and compatible with one another. Misinterpretation of relative and absolute coordinates, use of a wrong reference point or of a proprietary coordinate system can lead to major differences.
- High-resolution terrain level data generally available in raster files is getting more and more common. However, spatial resolution is not the same as accuracy. Furthermore, large data files can become a burden in the whole process. Therefore data optimisation is often needed to make the data fit for purpose.

C. Study of the Influence of Efficiency Settings on Calculated Results

Considering the huge amount of data that must be processed, efficiency settings are widely used in large-scale noise mapping application to optimise calculation time. In general, the calculation of such large-scale maps would not be possible using the so called “reference setting” as defined by DIN 45687 (i.e. the setting that ensures correlation with the known good results of the standard test cases of the calculation method). The use of efficiency settings introduces uncertainties which must be assessed and documented as part of the quality assurance process.

Noise mapping quality assessment according to DIN 45687 provides a statistical assessment of the accuracy relative to the quality of the calculation method in use. The standard considers that the calculation method itself has been quality approved. Furthermore, DIN 45678 considers that test cases are available to assess the quality of the calculation algorithms programmed in a given noise mapping software. The test cases must be standardised, designed in a way to thoroughly test the behaviour and specifics of the calculation method in typical propagation situations. For each test case, both known good results and their confidence interval must be publicly available: they constitute the reference needed to assess the accuracy. Test cases and results must be documented in a way that the calculation of the known good results can be understood and recalculated by qualified persons. The quality of the noise mapping software is then assessed by means of comparing results calculated for the standardised test cases with the known good results.

D. Comparison with Measurements

The comparison with sound level measurements provides a comparison with a physical quantity. Therefore, it can be regarded as a measure of "absolute accuracy" as opposed to the relative accuracy provided by statistical assessment methods of DIN 45687. The measured sound pressure level becomes the reference needed to establish the accuracy of the calculated results. The difficulty here is to ensure that both the measurement and the calculation are made in the same exact conditions. Variations in sound emission levels or meteorological conditions can lead to difficulties in comparing the measured with the calculated level. Furthermore, it must be made sure that the calculation method used is able to take into account all effects on the propagation path. Finally, the measurements must be made by experienced staff observing the procedures of the relevant environmental measurement standards.

5. CONCLUSIONS

A four-tier approach to assuring quality in strategic noise mapping has been presented. All these methods have been field-tested by the authors on real-world strategic noise mapping projects.

The need to develop a chain of logically sequenced tests stems from the complexity of the task: large-scale noise mapping is as much an exercise in GIS data processing as it is in acoustics calculation of noise propagation outdoors. Each single part of the noise mapping process must be covered by suitable QA tests. Testing may not start too late and cannot be limited to ensuring proper sound propagation calculation by a noise mapping software. Tiers one and two are concerned with both input data and calculation method. Only tier three of the system presented above ensures the quality of the noise mapping software.

The last two tiers concentrate on the aspects of relative and absolute accuracy. They differ in the sense that one attempts to establish an absolute measure of accuracy by determining the degree of agreement with a physical, measured reference, whereas the other determines a relative accuracy by assessing the quality of the implementation of a calculation method. Both methods have their merits. However, it is important to understand the semantic difference in the measures of accuracy that are used. This should be properly reflected in the documentation accompanying a final noise map.

A multi-tier approach makes sure QA is no longer an end-of-pipe process: it must be an integral part of all steps from data collection and procurement to modelling and calculation.

REFERENCES

[1] DIRECTIVE 2002/49/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of June 25 2002 relating to the assessment and management of environmental noise, Official Journal of the European Communities, L189/12-25, 18.7.2002

[2] Recommendation 2003/613/EC concerning the guidelines on the revised interim computation methods for industrial noise, aircraft noise, road

traffic noise and railway noise, and related emission data, Official Journal of the European Union, L212/49-64, 22.8.2003

[3] STOTER, J. (1999): Noise Prediction Models and Geographic Information Systems, a sound combination, SIRC 99 – The 11th Annual Colloquium of the Spatial Information Research Centre, University of Otago, Dunedin, New Zealand, December 13-15th 1999

[4] WG4 Annual Progress Report October 2000; 5 pages report prepared by John HINTON and Søren RASMUSSEN for European Commission DG Environment, unpublished

[5] Research for a quieter Europe, A Strategy Paper (including Technical Annex) of the CALM Network funded by the DG Research of the European Commission - July 2002, EUR 20436, European Commission, Research Directorate General

[6] ZHAN, J./GOODCHILD, M. : Uncertainty in Geographical Information, Taylor & Francis, London, 2002

[7] HEUVELINK, G.B.M. : Error Propagation in Environmental Modelling, Taylor & Francis, London, 1998

[8] DE KLUIJVER, H./STOTER, J. (2000): Noise Mapping and GIS: Optimising quality, accuracy and efficiency of noise studies, InterNoise 2000, Nice

[9] WETZEL, E./SERVE, C.: How to assure quality of Noise Mapping Software? Two approaches explained, Paper 729, Session C5-1, The 2001 International Congress and Exhibition on Noise Control Engineering, The Hague, The Netherlands, 2001 August 27-30

[10] Quality Assurance Handbook for Air Pollution Measurement Systems: Volume IV. Meteorological Measurements, United States Environmental Protection Agency, August 1989

[11] DIN 45687:2006-05, Acoustics – Software products for the calculation of the sound propagation outdoors - Quality requirements and test conditions

[12] KRAPF, K.-G./WETZEL, E.: Practical aspects of QA in noise mapping, Paper 348, Inter Noise 2009, Ottawa, Canada, 2009 August