UNCERTAINTIES AND ERRORS CAUSED BY THE USE OF NOISE PREDICTION SOFTWARE

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Introduction

Noise Mapping according to the EC directive about environmental noise and for the purpose of land development has become a valuable tool in all procedures of community and city planning. It is indeed a fascinating process for all noise experts to handle noise problems not on a microscopic scale with silencers, damping materials and sound stop windows but facing large scale problems with motorways, airports and other noise relevant constructions taking into account the consequences for hundreds, sometimes for thousands of km². For traditional acousticians this approach may be a bit suspicious because of the lack of knowledge about uncertainties – nevertheless the approach has proved it's capability in large projects that led to real noise reduction programs in the last years.

But it is also true that the methods of taking into account uncertainties must be improved. The GUM-approach [1] is well accepted in the standardisation of measurements in sound and vibration, and there is no reason why it shouldn't be used to evaluate the uncertainty of calculated sound pressure levels.

Main Influences on Uncertainties

Regarding the uncertainties in noise mapping results, we have to take into account uncertainties of these values:

Emission values – taken from measurements, literature or experience

Modelling – regarding sources, terrain, objects influencing propagation

Calculation – regarding lack of algorithms in standards, deficiencies of software, inadequate choice of method or use of software.

Uncertainties of emission values

The uncertainty of emission values can be taken into account by using the technique developed in [2]. The uncertainty of a measurement of sound power level depends on the standard that have been used – e.g. ISO 3741 – ISO 3747 – and is expressed as standard deviation of reproducibility s. The following standard deviations are in accordance with our experience resp. with published results:

SOURCE OF INFORMATION	STANDARD DEVIATION OF UNCERTAINTY
collegues	5 dB
literature general (machine family)	4 dB
literature specific (specified for machine and parameters)	3 dB
Measurement	
Grade 3 (e.g. ISO 3746)	4 dB
Grade 2 (e.g. ISO 3744)	2 dB
Grade 1 (e.g. ISO 3741)	1 dB

What we need is the sound power level of each source $L_{W,I}$ and the uncertainty of this value expressed as standard deviation s_i. From the propagation calculation we know the partial sound pressure level L_i – using the uncertainties of each emission value the uncertainty of the level at the receiver influenced by all sources is

$$s = \frac{\sqrt{\sum\left(s_i \cdot 10^{0,1 \cdot L_i}\right)^2}}{\sum 10^{0,1 \cdot L_i}} \qquad (1)$$

The following example is a power station with 3 stacks. It shows, that the uncertainty at the receiver 1 nearby is larger than that at receiver 2 – the larger the distance, the more compensate the uncertainties of all the sources.

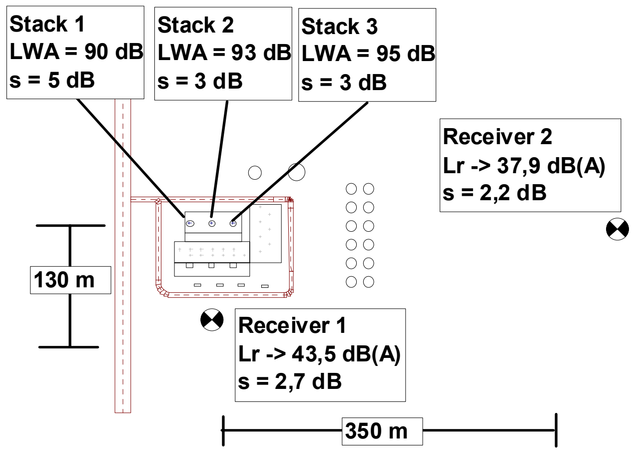

Figure 1: Uncertainty analysis with three stacks

The process used for extended sources like roads and railways is a bit more complex, because the different parts of these sources don't radiate independent. According to [2] this can be taken into account including the covariance into the calculation.

Uncertainty resulting from standards

The algorithms described in standards and guidelines are always incomplete and produce uncertainties, because the used physical models are – and must be - approximations. From experience we know that in some cases a more detailed modelling of the environment may even result in larger uncertainties than a more simplified description, because the latter is less sensitive to parameters that are not well known in most cases. The diffraction of a wave sweeping over lumped and irregular oriented objects cannot be described exactly by a ray model, even if some wave properties are taken into account looking to the extension of fresnel zones.

Diffraction is one of the most affording problems in all known propagation models. There are also many different approaches that take "a little bit" the wave and field theory into account – modelling real situations with complex geometries and looking to the level jumps produced by some of these methods the more simpler models using the ribbon tie method to calculate the diffraction path above and around all objects is often the more satisfying solution.

To test diffraction strategies we use randomly oriented buildings like shown in Figure 2. Using different methods helps to find the sensitivity of a procedure and its applicability.

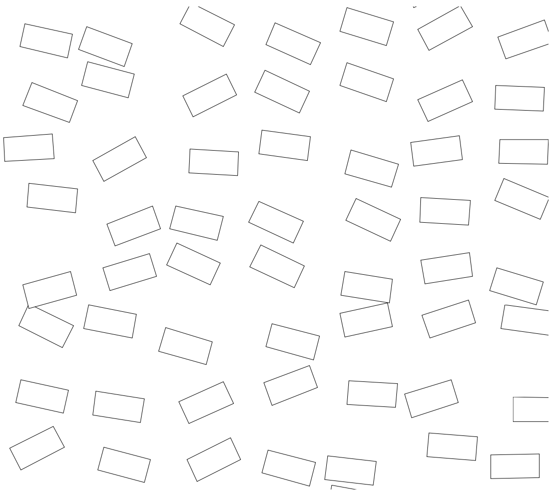

Figure 2: Irregular oriented buildings to test screening calculations

An important result from many years of experience in noise prediction calculation is the need of transparency and published procedures. The complexity of a method is not a proof for smaller uncertainties of calculated results. But it is very important that the results of a method are compared with measurements and published to be open for discussion of experts.

Deficiencies of Software used

Each software package uses approximations. With large scale noise mapping calculation times play an important role, and the more efficient a program is with respect to calculation speed, the better approximations can be used.

An example is the screening by terrain elevations. The contour lines or height points that define the ground height are generally imported – it is extremely time consuming and practically not possible to edit manually.

All software programs usable for noise mapping use additional calculated meshing lines to produce the ground surface. There are programs that show a nice shaped surface in 3D-view, but include only the existing contour lines like upper edges of barriers into the screening calculation. The two contour lines shown in Figure 3 produce the hill shown in Figure 4 – a program of the type mentioned will not calculate diffraction by the elevated slopy part of the hill. The noise level at the receiver produced by the point source is completely wrong, if calculation of barrier attenuation by the calculated lines of the mesh is not taken into account automatically. Such a test with this simple example is helpful – if the lines of equal sound levels are only distorted behind the contour line with 20 m height, it is clear that the modelling of the ground without time consuming control of the model will result in large uncertainties with hilly ground.

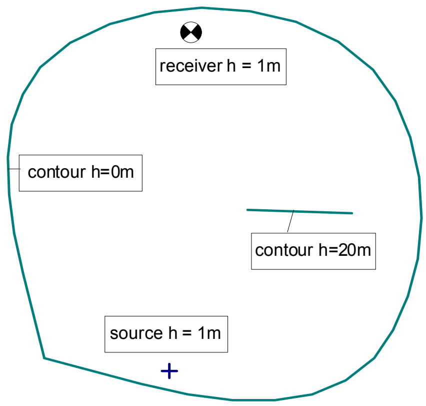

Figure 3 A simple situation of elevated ground

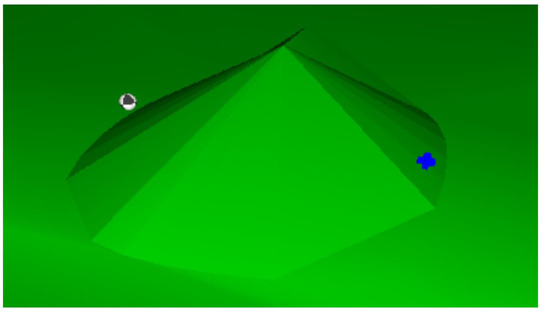

Figure 4 3D-view of the terrain model

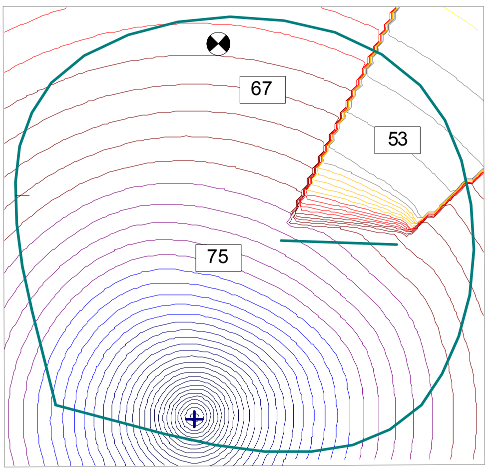

Figure 5 Lines of equal sound pressure level – no influence of the ground elevation at the slopy area

References

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