Techniques to support Noise Mapping, Noise Rating and Action Planning

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Introduction

The first round of Noise Mapping and Action Planning according to the European Directive about Environmental Noise should have been finalized now. Some countries have used their national calculation methods, some others applied the recommended interim methods. It was the declared opinion by the commission that a harmonized common method shall be used in the second round in 2012, but in the meantime it is questioned more and more if the planned approach with the Harmonoise method will available with the necessary clear description. It includes coherent superposition of sound waves and meteorological influences and is – from the point of view of the developers – therefore more accurate. But taking into account it's increased complexity it is also clear that it decreases precision and transparency. To weight these aspects noise mapping should not be seen as a target for itself, but it is necessary to weight effort and result by taking into account the final decisions that are based on these noise maps.

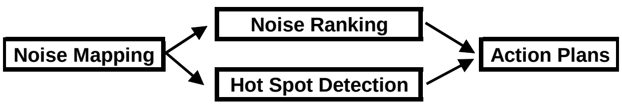

Figure 1 Noise Mapping is the first step to come to action plans

If we investigate critically and without biased opinion the deviations calculation – measurement in daily life situations in agglomerations we come to the decision that there are always ± x dB uncertainty that cannot be reduced because they are determined by unknown parameters of the traffic flows and other influences. Therefore it makes no sense to include more physical phenomena in the algorithms because this will only feed up the progress in hardware without an adequate increasing of the overall accuracy.

Uncertainties in emission values

Figure 2 shows the sound emission a road piece in dependence of speed for passenger cars calculated with different national methods. It shows that above 50 km/h there is an interval of 5 dB that can be defined to be roughly the uncertainty of the emission values. Taking this and many other aspects about the unavoidable uncertainties in emission values into account, the improvement by many newer developments in the calculation of sound propagation is relativesed.

Some of these improvements in newer methods are
- smaller frequency bands
- phase related emission to include coherent superposition of ground reflection and direct ray
- more source lines to represent a road

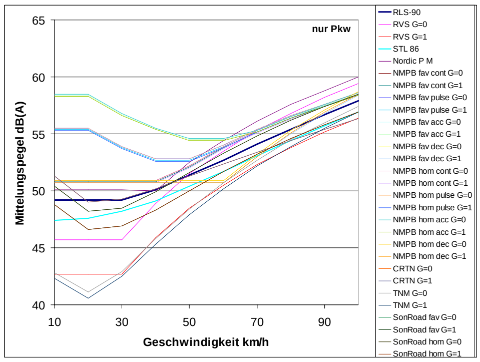

Figure 2 Emission of road piece calculated with different national methods.

All these influences have been investigated with respect to accuracy of the resulting level at a receiver position. The results will be published by BAST (Bundesanstalt für Straßenwesen, Germany).

Smaller frequency bands make only sense if all influences like road surface and tyres, speed, gradient of the road and other parameters can be expressed separately for each of these frequency bands. As long as these influences are only expressed as corrections to the total level the uncertainty of the resulting band levels are high and the calculation in smaller frequency bands increases only the complexity of the calculation without adequate benefit in accuracy.

The same is true for coherent interference of direct ray and ground reflection. The dips and spatial variations caused by interference have an extreme influence for small frequency bands, but vanish more and more if these levels are superposed to broader bands and at the end the A-weighted levels show the same behaviour as the levels calculated without taking into account frequency spectra. With respect to screening, reflection and ground effects it seems to be an acceptable compromise to calculate with octave bands.

In some models the source "road" is represented by one line source for each lane (NMPB), by two line sources one for each of the two outmost lanes (RLS-90) or by one line source with a position depending on the receiver position (CRTN). Calculated difference maps in vertical grids show that the RLS-90 method (two line sources) is a good compromise with uncertainties that are in line with the other uncertainties.

Taking into account the not predictable variations in the composition of the fleet, in the vertical distribution of effective sources for different cars, in the behaviour of car drivers and even diffraction of the sound from cars in one lane by the cars in the other lanes a very detailed modelling of the source "road" will only increase complexity and transparency without an adequate improvement with respect to accuracy.

Sound propagation

Calculation time is one of the critical aspects for mapping calculations – the noise map of a city can only be produced in acceptable times if certain acceleration techniques are used that on the other side reduce accuracy of the calculated levels. These uncertainties can be determined with techniques described in DIN 45 687.

Optimization of calculation speed versus uncertainty needs a thorough balance – all different contributions to the total uncertainty should be similar. If the accuracy in the determination of the influence of a certain phenomena is increased too much on expense of calculation time the total uncertainty will be increased if this calculation time shall be kept in certain limits. Therefore it should be tested thoroughly if a more detailed description and calculation in one part of the model will really produce a benefit regarding the result of the procedure.

The inclusion of meteorological effects is such an example. The abovementioned investigation has shown, that the inclusion of meteorological effects has nearly no influence on the noise exposure calculated at the buildings in agglomerations. Therefore it is not recommended to reduce the transparency and precision of the noise calculation with repeated calculations for different meteorological conditions according to their statistical time relevance.

One of these developments is a more detailed inclusion of meteorology. We investigated these effects by calculating the noise map of a city with NMPB and using alternatively the meteorological conditions of two different French cities and even with total favourable and homogene conditions – the difference map shows, that not one decision about possible action plans would be different in both cases. Based on these and other findings we are convinced, that it would be better not to propose more and more complex models as Strategic Noise Mapping is concerned and to base the harmonised method for the second round on existing empirical models to get the time for a thorough investigation of effort and benefit.

Ranking of Noise Exposures

All these aspects mentioned above are true for noise maps as well as for calculation of noise levels at building facades. In the latter case it is recommended to leave the concept of the Directive to use only the levels in 4 m height at the most exposed façade if decisions about noise reduction measures have to be taken – based on progress in hard- and software technology it is possible to take into account all floors and all facades of a building if the height of barriers or other measures shall be dimensioned.

If the noise exposure of the population in a certain area shall be compared and qualified for different scenarios, a single number rating should be used.

In the frame of the project Quiet City concepts have been developed to perform such a single number rating on the basis of noise maps. One of these concepts described in /1/ was used to detect the Hot Spot Areas where actions should be taken to reduce the noise. Another proposal takes into account more effects like annoyance, sleep disturbance and the risc of myocardial diseases. Annoyance is based on quantifying the number of highly annoyed people (%HA) according to the investigations of Miedema /2/.

The measure for annoyance %HA is derived from the Lden, the insulation of the living room (relative to the mean insulation of all buildings), the difference Q between most and least exposed façade and the ambient noise level A within a radius of 200 m around a dwelling.

Sleep disturbance is quantified and related to the Lnight and the insulation I of the bedroom relative to all the other buildings in that area.

The risc of myocardial effects is derived from the Lden.

Additionally the AREA 50 – this is the percentage of noise exposed area in the vicinity of a immission point – is calculated.

This HAP-calculation (Highly Annoyed Persons) has been implemented in the mapping software CadnaA /3/. The calculation of façade levels for the different noise sources is organized as different variants in the same project and the complete evaluation can be performed in one run. Principles and procedures are demonstrated.

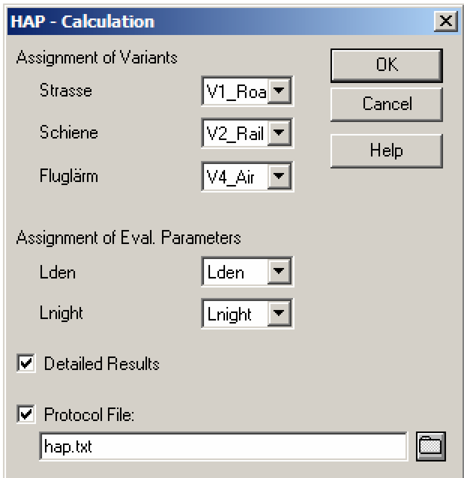

Fig. 3 Definition of the HAP-calculation in CadnaA

The results for each residential building are written into a result file and can be processed further.

References

[1] Probst, W.:, "Noise Rating and Noise Score", *InterNoise Proceedings 2006, Hawai*

[2] Miedema H.M.E., Borst H.C.: “Rating environmental noise on the basis of noise maps”, report Deliverable D1.5, project QCity, Feb. 2007

[3] Info about CadnaA : www.datakustik.com