Noise Mapping and Noise Scoring - Software Techniques and Result Presentation

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Noise scoring is based on noise level maps and on exposure distribution. Different techniques can be used to develop the areal distribution of these values and to present them as coloured maps. Especially more complex ratings that are not only based on an exposure level and on population densities, but take into account mean levels in an area surrounding the point of interest and other information need relatively complex procedures to develop them from noise maps. It must be taken into account that there are two important steps in this procedure: One is the calculation of the noise score itself and the other is the presentation as coloured map to detect and focus on Hot Spots. Different techniques have been developed, were integrated in software and have been applied in the frame of the QCity project. The consequences of different parameter settings are presented and discussed. The second step is the assignment of colours to a given scale of result values and even this simple process must be handled carefully to transport the needed information.

1 Introduction

The only reason for the European activities in noise mapping, noise evaluation and noise scoring, hot spot detection and action planning is the will to reduce the noise exposure for the population. The well known noise maps show the spatial distribution of noise and give an impression about the areas where certain limiting values are exceeded and where a more detailed analysis should be undertaken. But high noise levels alone are not a sufficient indicator for the necessity of measures, because the number of people exposed must be taken into account to qualify such a situation.

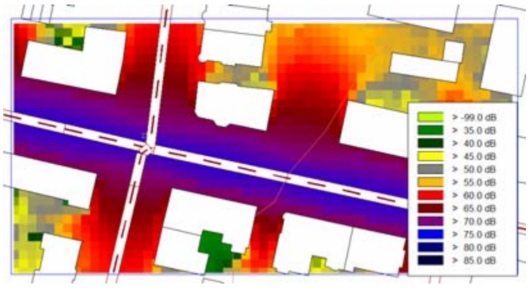

Fig. 1 Noise map of an area

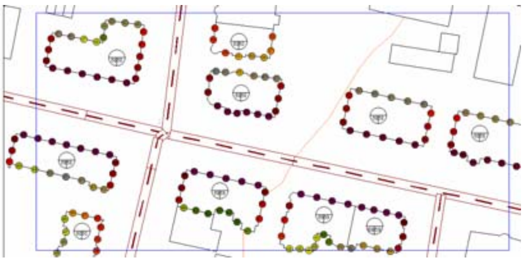

Fig. 2 Building noise map with calculation around the facades

To get the link between noise levels and people exposed the noise levels around the facades are determined. With these building noise maps the noise level for all relevant facade elements is known and with the number of residents of the building for each façade element, dwelling or even building the pair of values – number of residents and noise level – is known. It shall only be mentioned here that in some member states each façade element is used to produce such a pair of data, in others the highest level of a façade and in others the highest level of all façade points of a building is used.

2 Techniques of Spatial Averaging

Noise maps are a simple presentation of the noise level that has been calculated at receiver points located on a grid covering the area of interest. This type of presentation is not very helpful if we want to show for larger areas the spatial distribution of data that are linked to buildings or other irregularly distributed sub-areas. An example is the presen-- tation of the spatial distribution of population density, of the building heights or of the number of residents in a building as a coloured map. These cases need a spatial averaging of the information to be presentable with larger scales.

This spatial averaging can be performed automatically inside the Noise Prediction Software CadnaA. The user can define the dimension of a square , e. g. 100 m.

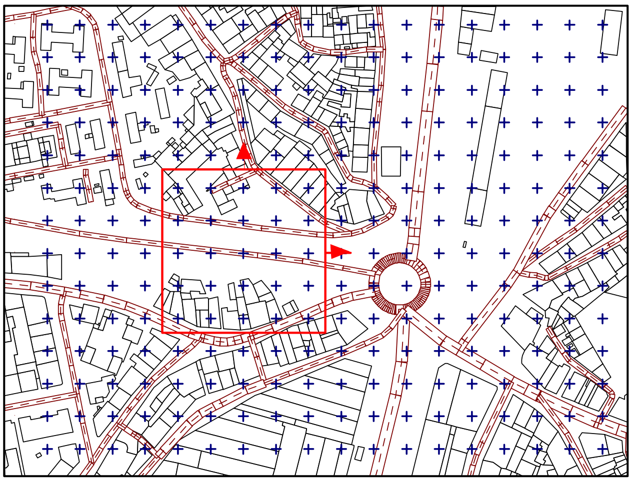

Fig. 3 Averaging inside the square to get the value for the center grid point

This is square is centered on a grid point, the calculation is performed with all objects inside the square and the result is summed up and normalized with any user defined expression. The calculated value is then the result attached to the grid point in the center. The square is then moved one grid spacing – e. g. 10 m – and the process is repeated. At the end we get a spatial distribution of the result value calculated for each position of the square.

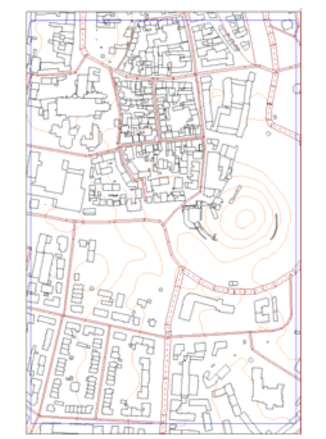

Fig. 4a Section from city model

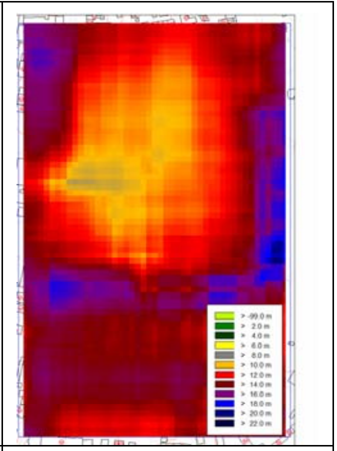

Fig. 4b Mean height of buildings

Figure 4a and 4b is an application of this technique to present the mean height of buildings as a coloured map.

3 Noise Evaluation and Noise Scoring

3.1 Problem definition

The calculation of noise levels is a task without any degree of freedom, if well defined methods according to national, European or International standards are used. Figures 1 and 2 show different possibilities to present such spatial noise level distributions.

If noise mitigation measures shall be planned, noise levels alone are an insufficient basis to decide about priorities. Not only the height of the noise level, but also the number of people exposed to that noise is important. One of the basic question is:

If two persons are exposed to noise – is it better if one person is exposed to a certain level L and the noise for the other person is negligible or is it better if both persons are exposed to the noise with level L – 3 dB?

To decide about the best alternative between different noise distributions in a given area it is necessary to find a single number rating, because only then these different situations can be scaled.

3.2 Counting Numbers above Threshold

In many cases noise problems are ranked by counting people with a noise level above a certain value. In the Czech republic Hot Spots are identified in noise maps by using the technique explained in chapter 2 to present the areas where most of the residents in this gliding window are exposed above 70 dB(A).

This technique to count the residents above a certain level limit are methodically wrong and even dangerous if the consequences are taken into account. Dangerous because at a first glance the results seem to be plausible, but it can easily be shown that the application of this technique results in strange recommendations for the best suited mitigation program.

If the number of persons above 70 dB are used to rank the noise problem and a certain budget can be used to apply measures, the best effect results if some dB reduction in areas slight above 70 dB(A) are achieved. Based on this weighting system a community will never reduce noise levels from 75 to 72 dB, because this has no consequence for the resulting score, but reducing levels from 72 to 69 dB will decrease the noise score.

A similar principle is behind the application of the HA – concept (HA → highly annoyed). It is hidden behind a lot of questionnaires and studies, but this concept is nothing else but a counting of numbers above a threshold.

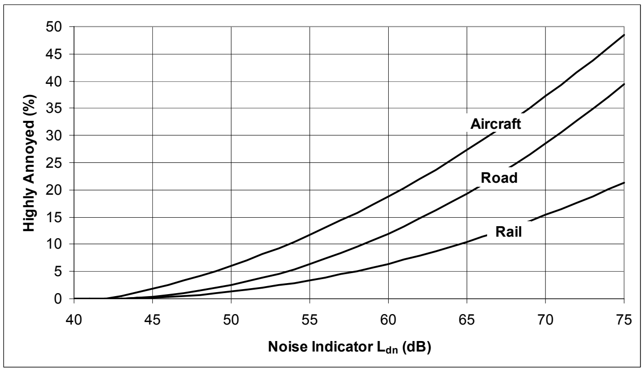

Figure 5 The percentage of highly annoyed persons in dependence of noise exposure

The percentage of HA for different noise types as shown in figure 5 can be derived from questionnaires – it is a strongly determined relation. But this curve is not a good measure for the overall noise problem, because it neglects the increase of annoyance with increasing level for most of the residents. Only looking to the percentage of HA produces an extremely weak dependency level → Noise Score – the (wrong) conclusion is that levels can be even increased if the exposure for residents living with lower levels is reduced.

3.3 Continuous Scoring

In /1/ the principles of Noise Scoring have been developed and a model of reaction of a population on noise exposure was presented. This model proves that curves like shown in figure 5 depend only on the different sensitivity of residents and has nothing to do with the increase of annoyance with increasing level.

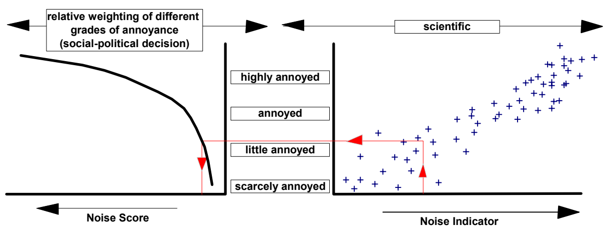

Figure 6 Relating noise exposure to a Noise Score

There is no scientific evidence how different grades of annoyance can be weighted relatively. It cannot be derived from scientifically based principles for how many slightly annoyed persons we must reduce the level by X dB to compensate the level increase of one highly annoyed person by the same amount of X dB. This is a social political decision, and the HA concept is only a try to hide this behind scientific argumentation.

In fact a realistic scoring system should include two steps. Right hand side of figure 6 shows the relation Noise level → grade of annoyance –these dependencies can be derived from studies and questionnaires. But then we must weight these grades of annoyance against another, as it is shown at the left side of the diagram. The product of these two factors is the wanted Noise Score, that should be used to get a valuable quantity representing the seriousness of a noise situation.

Based on an investigation of the consequences of weighting systems (see /1/) the following Noise Score function was derived.

$$NS = \left(\sum_i \begin{matrix} n_i \cdot 10^{0.15 \cdot \left(L^*_{den,i} - 50 - dI + dL_{source} \right)} & with\ L^*_{den,i} \leq 65\ dB(A) \\ n_i \cdot 10^{0.30 \cdot \left(L^*_{den,i} - 57.5 - dI + dL_{source} \right)} & with\ L^*_{den,i} > 65\ dB(A) \end{matrix} \right. \quad (1)$$

with

NS Noise Score

n_i number of persons exposed with level $L_{den,I}$

$L^*_{den,j}$ Effective noise indicator at the relevant façade at dwelling i

dI deviation of mean sound insulation of dwelling i from the mean insulation of all dwellings

dL_{source} correction that accounts for different reaction versus noise from roads, railways, aircraft and industry

In our projects we use the noise indicator L_{den} because it includes all time-intervals.

4 Application

The Noise Score is a second step after the noise mapping that can help to assess a spatially distributed problem, to find out the Hot Spots where mitigation measures should be applied and to rank different alternatives for noise reduction programs if only restricted budgets are available.

Figure 7 shows the noise map of a city in 3-D-presentation.

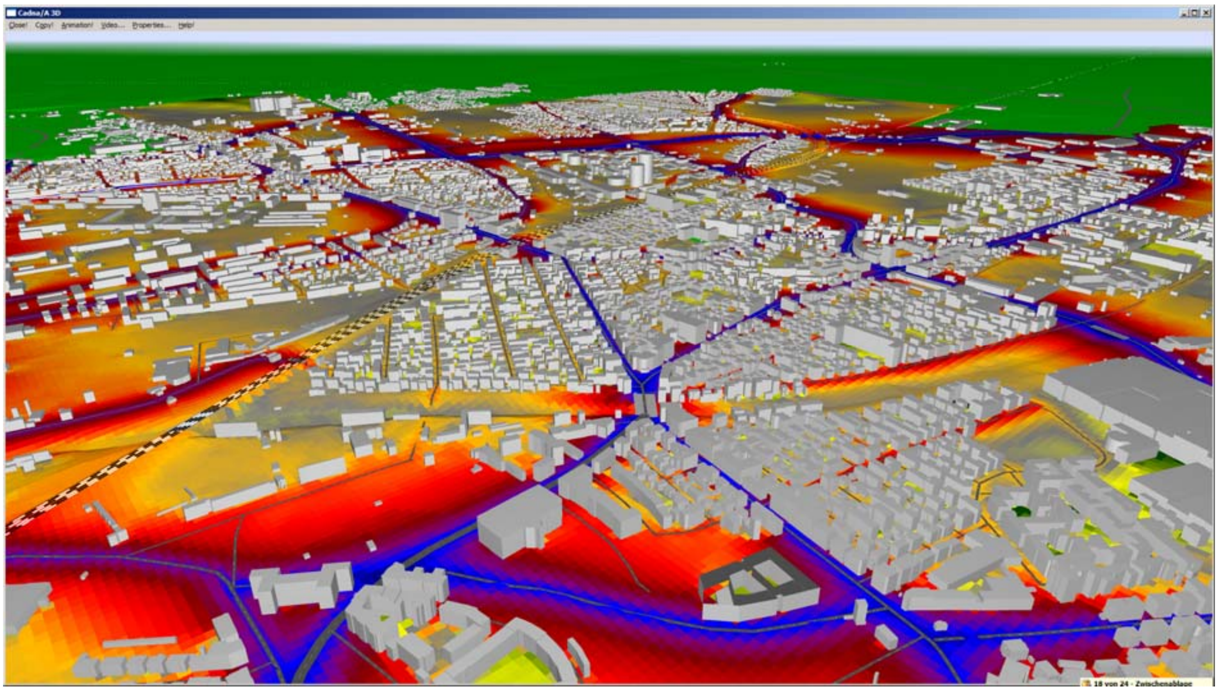

Figure 7 Noise Map in 3D for a city with 80.000 buildings

It is possible to walk through this city, to drive along the road or to fly over it virtually to inspect the noise impact caused by road and railway traffic.

Now equation (1) was used to calculate the Noise Score for each individual building using the number of residents and the noise level related to each façade point as shown in figure 2. Then the Noise Score was spatially averaged applying the technique explained in 2. If the upper 10% of all area-related Noise Scores are colored red, we get a Hot Spot analysis for this area. Figure 8 shows this Hot Spot presentation in the same view as it was shown in figure 7 for the noise map.

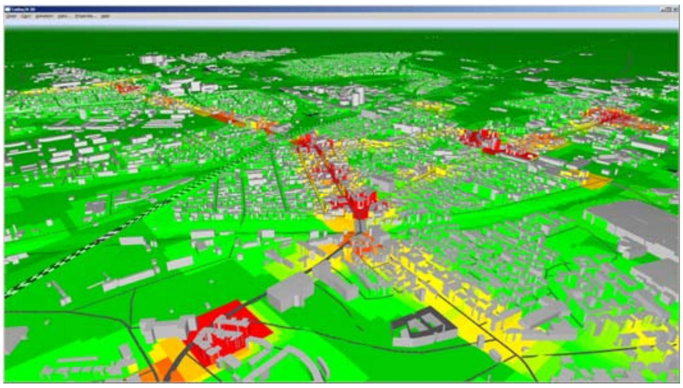

Figure 8 Hot Spot analysis and its presentation in 3D

If packages of noise mitigation measures shall be evaluated, the noise map is recalculated and the resulting Noise Score is summed up for the whole area. This makes the plenned measures transparent and offers an optimal basis to discuss it between experts and non-experts.

References

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