AN APPROACH TO REDUCE ENVIRONMENTAL NOISE:-HOW EUROPE USES NOISE MAPPING AND ACTION PLANNING

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ABSTRACT

According to directive 2002/49/EC many Noise Mapping Projects are in progress or even have been finalized. These noise maps are to be used as planning tools to develop effective noise reduction measures. The basic problem is that noise is only one, and in many cases not the most important, hazard that influences the decision about the success of such an approach. Air pollution, mobility and an unrestricted flow of goods on roads are also aspects that have to be taken into account. Basis of a successful approach is a ranking of alternatives. It is shown how these problems are tackled in the frame of the European project QCity and examples are presented.

1 INTRODUCTION

The aim of the project “QCity (Quiet City)” [1] is to develop an integrated technology infrastructure for the efficient control of road and rail ambient noise. A major objective is to provide municipalities with 1) methods to establish noise maps and action plans (Directive 2002/49/EC) and 2) a broad range of validated technical solutions for the specific high-priority problems (Hot Spots) they encounter in their specific city. A main target of the project is to support cities in the development and evaluation of action plans in the frame of the EC-Directive.

The main points are

- Using existing data of cities or other municipalities for the calculation of noise maps
- Modifying these and adapting them on the basis of the noise metrics, L_{den} and L_{night}
- Calculating the strategic noise maps and the levels at the façades
- Developing a system that can be implemented in software to evaluate and rank different alternatives for a given scenario on the basis of exposure - effect relations
- Investigating the recommendable noise reduction measures (general ones based on inventory and specific ones based on technological development in the project) taking into account acoustic effects, conditions for applicability and costs.
- Planning examples based on scenarios of the cities involved with ranking of different alternatives

This in a certain way iterative procedure is demonstrated in the following.

2 THE SYSTEMATIC APPROACH

Figure 1 shows the general approach how the problem is tackled.

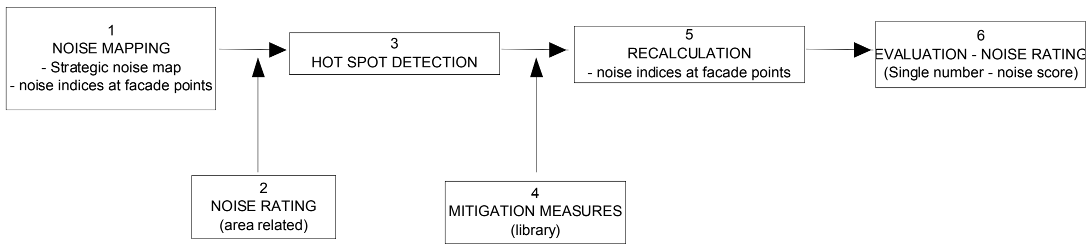

Figure 1: The general approach to reduce noise based on strategic noise mapping

The first step is to create a 3D-model of the environment with all relevant noise sources and to calculate strategic noise maps. The following actions are necessary:

- Data acquisition
- Control of data, if necessary conversion and modification of data
- Import of data and creation of the computer model
- Control and validation of the model
- Calculation of strategic noise maps based on EC-noise-indicators
- Determination of noise indicators at the most exposed façades

At the end of this investigation the horizontal distribution of noise levels, the noise level at the façade of each dwelling and the number of inhabitants in each dwelling is known.

Step 2 is the application of a noise rating system (Noise Score) to take into account the noise level and the number of people exposed. Two strategies have been proposed and the pros and cons of both are investigated.

Step 3 is the detection of Hot Spots: to produce a colored map to present the spatial distribution of the Noise Score. The techniques have been developed and are applied.

Step 4 is the development of a catalog of mitigation measures. Giving this catalog of measures to the cities helps provide support the noise reduction activities effectively.

Step 5 takes into account the different alternatively possible mitigation packages, and the calculation of noise maps is repeated.

Step 6 sums up the Noise Score for the complete area. The best alternative can be found by minimizing this value.

3 NOISE MAPS – HORIZONTAL DISTRIBUTION AND AROUND FAÇADES

The noise mapping techniques are well established [2] – Figure 2 shows the noise map of Stuttgart – Fildern area where the mentioned procedures have been applied.

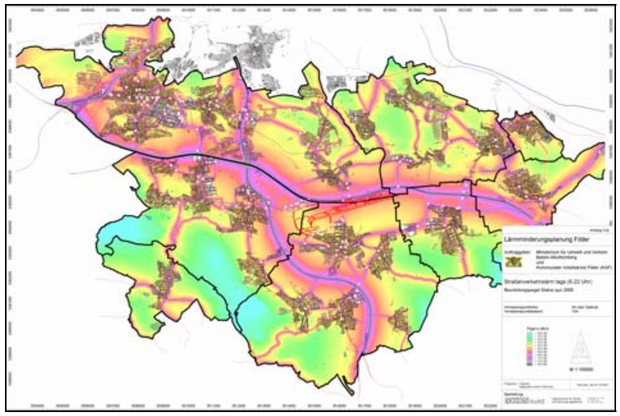

Figure 2: Noise map of the Stuttgart-Fildern area (road traffic noise)

The second type of noise calculation is shown in Figure 3. The receiver points are distributed around the façades at all floors and using these and the noise indicators L_{den} and L_{night}, the most exposed façades are determined. Further, the number of residents in each dwelling or building is associated to the building object and can further be used as one of its properties.

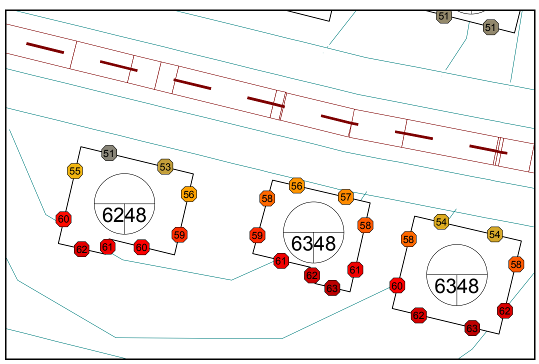

Figure 3: Building noise map: Level distribution around building façades

4 NOISE RATING SYSTEM

Two approaches to noise rating have been investigated and are applied. The first one was developed by Miedema [3] and takes into account the effects annoyance, sleep disturbance and the risk of myocardial effects.

4.1 Annoyance

is quantified by a value that depends on the level at the most exposed façade, L_{den}, the sound insulation of the living room, I, the difference between most and least exposed façade, and the ambient noise level within a circle of radius 200 m around the dwelling.

4.2 Sleep disturbance

depends on the noise indicator L_{night} (at the most exposed façade) and the insulation I of the bedroom

4.3 The risk of myocardial effects

depends on the L_{den} (level at the most exposed façade) according to this method.

The second Noise Rating system was published in [4] and will be used in the project examples described below. The Noise Score is calculated from

$$NS = \left(\sum_i \begin{array}{ll} n_i \cdot 10^{0.15 \cdot \left(L_{den,i} - 50 - dI_i + dL_{source}\right)} & with\ L_{den,i} \leq 65\ dB(A) \\ n_i \cdot 10^{0.30 \cdot \left(L_{den,i} - 57.5 - dI_i + dL_{source}\right)} & with\ L_{den,i} > 65\ dB(A) \end{array} \right. \qquad (1)$$

Where

NS	Noise Score
n_i	number of persons exposed with level $L_{den,i}$
$L_{den,j}$	noise indicator at most exposed façade at dwelling i
dI_i	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

This Noise Score takes into account that, above 65 dB(A), the risk of noise induced diseases cannot be neglected.

5 HOT SPOT DETECTION

After evaluating Equation (1) for each building or dwelling, the building related Noise Score is known and can be used to present these buildings with different colors.

The spatial distribution of this Noise Score is produced using the technique shown in Figure 4.

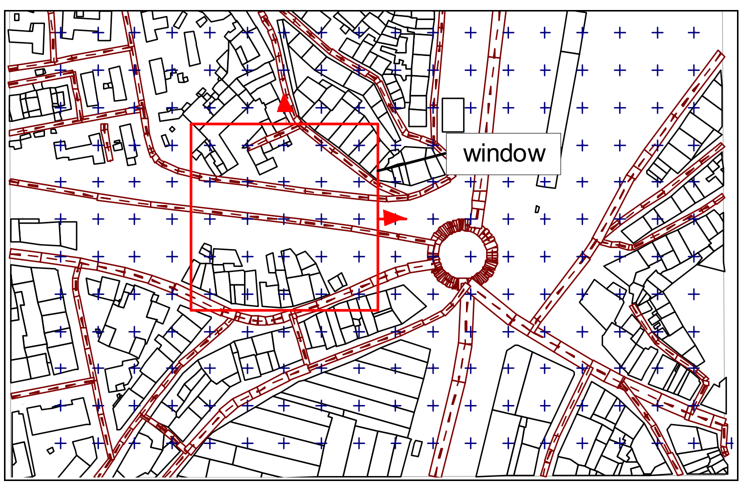

Figure 4: Building noise map: Level distribution around building façades

The basics are as follows: the receiver points are regularly distributed on a 10m x 10m grid. A calculation window with given dimension – generally 100m x 100m – is centred around a grid point, the Noise Score of all buildings inside the window is summed and the determined value is divided by the window area and multiplied by 1000. This Noise Score value per 1000 m² is attached to the grid point in the centre of the window. This procedure is repeated for all grid points and at the end the Noise Score is shown as gliding average for the whole area. Using a certain colour – e.g. red – for the highest noise exposure values, the resulting map shows the Hot Spots where the area specific Noise Score is largest.

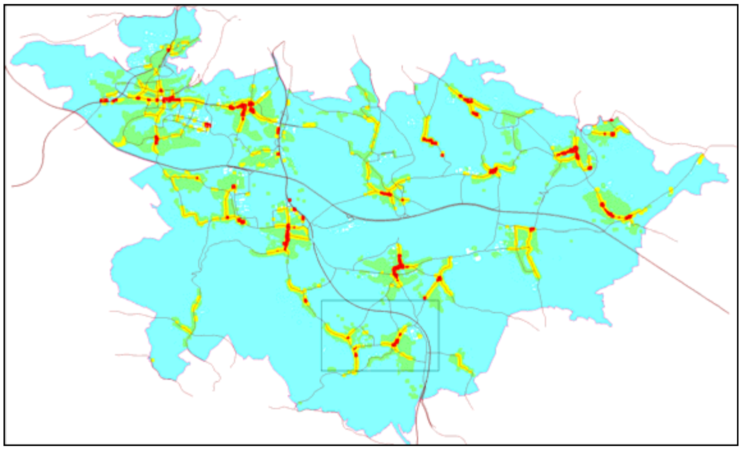

Figure 5: Building Detected Hot Spots

In the case shown the distribution of Hot Spots is completely different from the noise map Figure 2 – red are the road segments crossing little villages with narrow roads where the distance between traffic and windows of dwellings is small. This distribution of Hot Spots is the starting point to develop mitigation packages.

6 CATALOGUE OF NOISE REDUCTION MEASURES

The core of the project is a catalogue of noise mitigation measures that can be applied by cities and communities. This catalog includes well known measures with well known applicability and performance as well as new developments where only theoretical knowledge exists. For these latter cases, the information can be used to develop them further.

Examples on noise mitigation are measures like low noise road surfaces, special low height barriers near railway and tram tracks and even the prohibition on truck use in certain sensitive areas.

In the QCity project, examples using a low noise truck routing program are investigated. The complete road network is simulated in a special traffic flow calculation program, and inputs and outputs are linked with the noise calculation program.

If the passage of trucks is prohibited in one of the roads, the redistribution of traffic including all the other roads is calculated and the resulting traffic flow numbers are exported to the noise calculation program. After calculation of modified noise maps and façade levels, the Noise Score is calculated for all buildings and summed up for the complete area. This procedure is repeated taking into account different possible packages of transit prohibitions.

7 DETERMINATION OF AN OPTIMAL MITIGATION PACKAGE

It seems a simple task to find the most effective mitigation package by minimizing the total Noise Score summed up for all buildings in the whole area. But experience shows that not only aspects of noise, but also political influences have to be taken into account.

Figure 6 shows the change in Noise Score summed up over political units (communities with their own administration), if truck passage is prohibited for three roads. In the communities with reduced truck traffic and also in some neighboring communities, the Noise Score is reduced. But although the Noise Score in the whole area and in most of the communities is reduced, there are two areas where the Noise Score will be increased slightly.

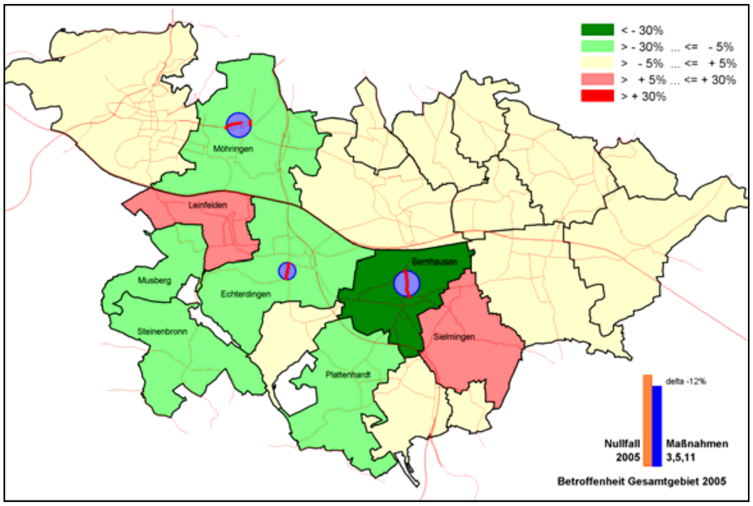

Figure 6: Distribution of Noise Score in 8 communities affected by the modified traffic flows.

These two communities will oppose the investigated redistribution package, because the municipal leaders cannot accept a concept where the noise exposure of most of the population is reduced without any advantage for their voters.

Noise mitigation concepts must take this into account. Such a concept must not only reduce the total and averaged noise exposure, but also the noise for each political unit separately. Otherwise it will not be supported by the relevant administrations.

8 REFERENCES

[1] Quiet City Transport: Contract TIP4-CT-2005-516420 (see http://www.qcity.org).

[2] Probst W., Huber B.: "A Comparison of Different Techniques for the Calculation of Noise Maps of Cities," Proceedings InterNoise 2001, The Hague, Netherlands.

[3] Borst, H. C., Miedema, H. M. E. (2005). "Comparison of Noise Impact Indicators, Calculated on the Basis of Noise Maps of DENL," ACTA ACUSTICA, Vol. 91, 378 – 385.

[4] Probst W.: "Noise Rating and Noise Score, "Proceedings InterNoise 2006, Honolulu, Hawaii.