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QUIET CITY – A EUROPEAN PROJECT TO SUPPORT CITIES IN NOISE MITIGATION

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Abstract

With the EU-Project "QUIET CITY" a broad approach has been undertaken to tackle environmental noise in European cities. Basis are the 3-dimensional virtual city models that are used to produce large scale noise maps keeping all parameter dependencies and traffic influences. Taking into account effect-annoyance relations, scoring techniques have been developed and these are used to find the hot spots where many people are unacceptably affected. A catalogue of mitigation measures has been developed that can be used by administrations and consultants to derive well adapted noise reduction programmes. Alternatively discussed packages are implemented in the 3D-city models, the noise maps are recalculated and based on the Noise Scoring System the solutions are ranked.
The described techniques have been tested and are demonstrated with real projects, e. g. Augsburg, Stuttgart, Stockholm and some others.

1. INTRODUCTION

The target of the QCity project is to develop an integrated method to support cities and communities to work out action plans based on the strategic noise maps calculated in accordance with the directive 2002/49/EC (European noise directive about environmental noise – END). All important and necessary steps are included from the development of assessment methods based on the effects of noise and taking into account noise exposures and numbers of people exposed, working out catalogues of mitigation measures up the ranking of alternatively possible packages of noise mitigation measures.

The project is carried out by 27 project partners. They work on different subprojects related to the implementation procedures in their countries. These subprojects are adjusted to produce a unique strategy that covers most of the problems of communities and administrations involved according to directive 2002/49/EC.

In the following some parts of the work carried out by the authors is presented including the development of noise maps, in some cases adaption of existing noise maps to the EC requirements, the method to find the "hot spots" and the ranking of different planning alternatives using the example of traffic redistribution. This is only a little part of the project – it will be supplemented and published via Internet step by step the next years.

2. THE CONCEPT

The partial aspects are dealt with in 5 subprojects. These subprojects 1 to 5 are the following

- SP 1 - Modelling and noise mapping
- SP 2 - Vehicle sources
- SP 3 - Vehicle/Infrastructure interface
- SP 4 - Propagation and receiver parameters
- SP 5 – Design and implementation of solutions at validation sites

and further 2 subprojects dealing with dissemination and management.

The program started in 2004 and has a duration of 4 years.
In subproject 1 the necessary steps to develop an action plan are investigated in some parts of the cities participating in the project.

In a first step existing 3D-models are adapted to the requirements of the directive about environmental noise – this means that the maps have to be recalculated based on the EC noise indicators L_{den} and L_{night}. Generally each member state (MS) can use his own national calculation method in the first round of noise mapping if certain adaptions are implemented to ensure comparable results. The cities Augsburg, Stuttgart, Stockholm, Gothenburg and some more take part in this investigation.

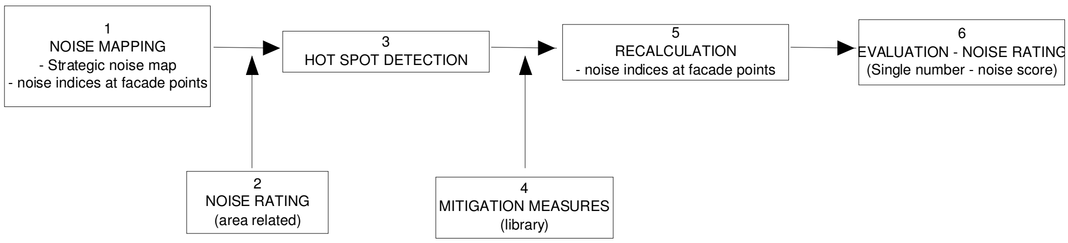

Figure 1. The main steps to develop an action plan

In Figure 1 the main steps of this investigation are shown. Steps 1 – 3 are finalized till now.

3. NOISE MAPPING

In step 1 the 3D-models of the cities and the noise maps are developed or – in most cases – adapted to the END requirements. In all cases it was necessary to implement more detailed source parameters like the traffic flows for day and evening separately to be able to calculate the noise indices L_{den} and L_{night}. In some cases – e. g. for the 800 km² Stuttgart area – the complete 3D-model was developed, because such a model has not been created before.

The availability of input data was completely different in the cases included. In the Stuttgart area Laser scan data in a very tight spacing and so the ground heights in the complete area where available, while the buildings where only known as 2 dimensional polygons. Figure 2 shows the superposition of these ground heights (presented as coloured map) with the building polygons. With a special object scan feature provided by in the noise calculation software CadnaA [1] the z-coordinate of all height points inside a building polygon are averaged and this value is interpreted as height of the building. Based on this procedure the buildings have been extended from 2D to 3D and integrated into the environmental model.

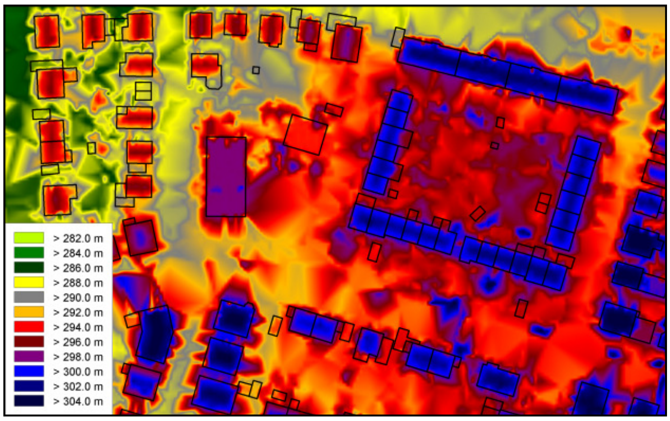

Figure 2. The generation of building heights from Laser scan points

In these cases it was possible to take all necessary data from existing data sources or – in some cases – to derive them more or less automatically from existing data. An example for the latter is the estimation of the number of residents in buildings where these data are not available – in these cases we use the area of the building polygon and the building height and assume a mean area per person to calculate the number of inhabitants.

4. NOISE EVALUATION AND RATING

Different strategies have been developed and recommended to get a single number noise score for a given scenario with any number of people exposed to different noise levels.
Type 1 commonly used is based on counting the number of highly annoyed persons. This commonly used method was one of the alternatives used also in the frame of this project [2].
In [3] the shortcomings of this method have been proven. It is shown that this method is equivalent to an extremely weak weighting of levels – a person exposed to 70 dB(A) is ranked equal as 2 persons exposed to 62 dB(A). In the consequence such an evaluation system recommends in all cases the bundling of traffic because it reduces this type of noise score in all cases independent of the level in front of the windows of the most exposed facades. It is also shown that the concept based on the HA value is methodically wrong because the rating function is not influenced by the steepness of the individual functions noise exposure – annoyance, but only on the dispersion of these functions for a given population.

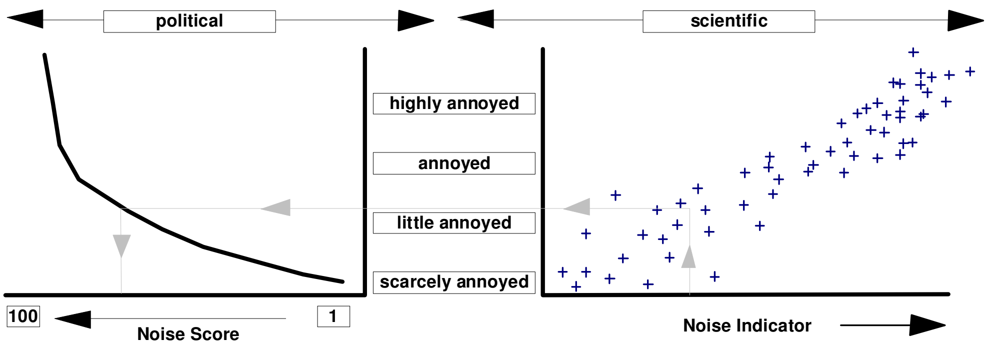

Figure 3. Two step procedure to relate the noise score to the noise indicator

Figure 3 shows the evaluation process as a two step procedure. The right side shows – only pictorial schematic – the result of different questionnaires about the grade of annoyance caused by a given exposure expressed by the noise indicator. Replacing the verbal qualifications about the grade of annoyance at the ordinate by numbers and attaching a numerical instead of a verbal scale is equivalent to a second step that implements a relation

between these different grades of annoyances. This second step is not evidence based and therefore open to discussions. At the end it's a political decision for how many persons living with 60 dB(A) the level must be decreased by X dB that this improvement compensates the increase of the level of X dB for one person with an existing exposure of 70 dB(A). Based on our knowledge of the living quality in dependence of the noise exposure the following relation was used to calculate the noise score
Type 2:

$$Y = \begin{cases} \sum_i n_i \cdot 10^{0,15 \cdot \left(L_{den,i} - 50 - dl_i + dL_{source}\right)} \; with \; L_{den,i} \leq 65 \; dB(A) \\ \sum_i n_i \cdot 10^{0,30 \cdot \left(L_{den,i} - 57,5 - dl_i + dL_{source}\right)} \; with \; L_{den,i} > 65 dB(A) \end{cases} \tag{1}$$

Y is the noise score to be determined, $L_{den,i}$ the noise indicator characterizing the noise in front of the façade of flat i, dl_i the deviation of the mean insulation of flat i with respect to noise outside relative to a mean for the whole area, dL_{source} a correction to account for different reaction of people on the noise sources road, railway, aircraft and industry. In this project the latter two parameters are not taken into account and set to 0.

5. HOT SPOT DETECTION

Starting point of the determination of the noise score Y for the evaluation are the façade levels – these are the values of the noise indicator L_{den}. These levels can be interpolated from the calculated strategic noise maps, but this method is quite inaccurate in inner cities where the grid spacing of 10m is often similar to the width of narrow roads. Therefore with a second calculation these façade levels are calculated directly for all residential buildings. The noise score is summed up for each building and the value of the "building related noise score" is used as one of its attributes further.

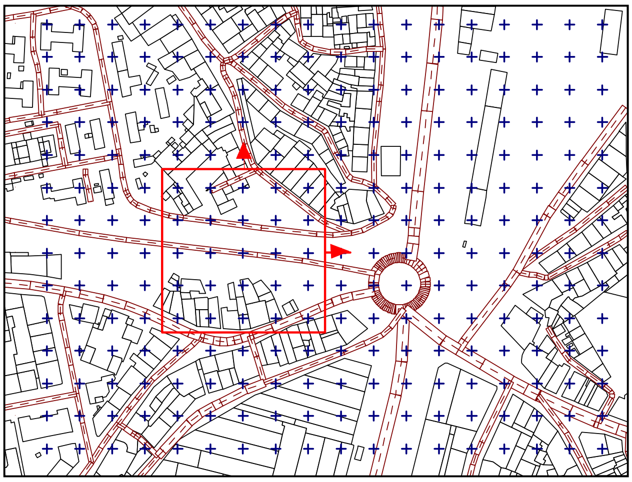

Figure 4. The production of a map of area related noise scores

To find out the hot spots – these are areas where people are exposed to noise exceeding a defined limit – a coloured map is produced representing the distribution of area related noise scores. A quadratic polygon 100 m x 100 m is centered on each grid point of the 10 m grid and the noise scores inside this square are summed and related to a definable area – generally an area size of 100 m² was used. When summing up the building related noise scores inside the window only a part of the noise score proportional to the part of the area of the building polygon inside the window is taken into account. If the three colours red, yellow and green are used for > 90 %, 10 % - 90 % and < 10 % of the complete interval of all values a clear indication of hot spots is presented.

5. NOISE MITIGATION MEASURES AND ACTION PLANS

It is not part of this paper to describe the further steps – they shall only be mentioned here.
Step 4 – shown in figure 1 – is the creation of a library with mitigation measures. These measures include low noise surfaces, special low barriers with small distance to railway lines where especially the safety aspects are tackled and many other developments up to low noise tyres. Some of these product-oriented measures are produced as prototypes and applied at test sites.

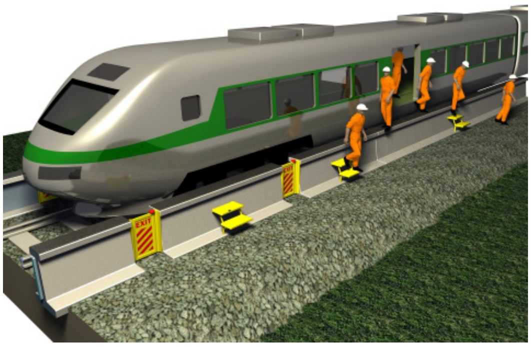

Figure 5. Low barriers to screen the noise produced at the wheel-rail contact point

For all these measures datasheets are developed that inform about the applicability of the method, the cost and the achievable noise reduction.

Another type of noise mitigation is based on traffic redistribution. In part of the Stuttgart area a low noise truck routing program was developed on the basis of a hot spot analysis as described before. The traffic in the complete road network was simulated with a software tool and the noise maps as well as maps showing the area related noise scores where calculated for the time before and after the measures have been implemented. This step 5 (figure 1) needs to import the traffic flow data from the traffic flow simulation software (Visum) to the noise calculation and evaluation software (CadnaA).

Summing up the noise scores in the complete area influenced by the measures gives an indication of the success – or the inefficiency – of the measure.

Many other aspects and investigations have been and are included in this project. The results shall support cities and communities to decide about promising noise mitigation packages that are adapted to their individual needs.

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