Interactive Noise Maps as Decision Tool

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Introduction

In the beginning the Environmental Noise Directive (END - Directive 2002/49EC) was planned more or less as an awareness raising instrument. Ten years after entering into force, the END is more than that. It became a powerful planning instrument for a quieter urban future. To achieve this one has to convince many local and regional stakeholders to support this aim politically and financially. Therefore it is suggested to use respective planning tools, such as interactive noise maps. This type of noise maps help laymen to understand how complex the noise mitigation business is. Further these stakeholders (and citizens suffering from noise) have to be enabled to decide fast and easily, whether a noise mitigation measure is effective or not.

Idea and aim of interactive noise maps

The Environmental Noise Directive of the EU aims to increase the noise protection of the population. The relevant guidelines for Germany are written down in the Federal Immission Control Act (Bundes-Immissionsschutzgesetz - BImSchG, articles 47 a-f). In a perennial process of noise mapping in cities and communities acoustical data are determined for areas which are exceptionally affected by noise.

Activities to reduce noise and to decrease the number of people exposed to noise are developed in the so called noise action plan, which follows the noise mapping and is based upon it. These activities should be checked in terms of their effectiveness and then be presented in the framework of public participation. But there are also other cases where noise mitigation measures are necessary and need discussion and evaluation.

Noise maps and façade levels of a city are usually calculated area-wide based on a three-dimensional model. This three-dimensional acoustic model includes beside the information about the heights and reflection properties of buildings and noise barriers, information of the streets and terrain characteristics (dams, cuttings, embankments, and troughs, mounds, hilly / flat profile). Depending on the computational capacity and the size of the area these calculations still require several days to several weeks for large-scale noise mapping.

After the calculation focal points of noise are identified and first suggestions for noise reduction are made. These suggestions are developed in dialogue with concerned people and professionals (urban planners, traffic planners, acousticians) and decision makers of the local politics.

Experts can debate the proposals during such events usually qualitatively, but not quantitatively. So the impact of reduction on a source can only be guessed rudimental for conflict areas with multiple sound sources. To assess more specifically the effects of measures which are taken from a participatory process a recalculation of the model is needed in adequate time. The results (and possibly the basis for decision) can only be shifted on a later date (after the time of investment).

Figure 1: Classic approach to evaluate measures

Because of this LÄRMKONTOR tried to find a possibility to speed-up the evaluation of noise mitigation measures

- to optimize the participation of the public,
- to make effects more transparent and
- to enable fact based discussions as well as
- to help noise action planning with the
    - identification of hot spots,
    - analysis of noise sources and
    - development and evaluation of noise mitigation measures.

As a result, a software tool was developed to speed up the recalculation process. Many changes in the model scenario can be analysed in extremely short-term with the "interactive noise map". Noise mitigation measures at source can be checked and can be presented with their effects on areas and façades in seconds.

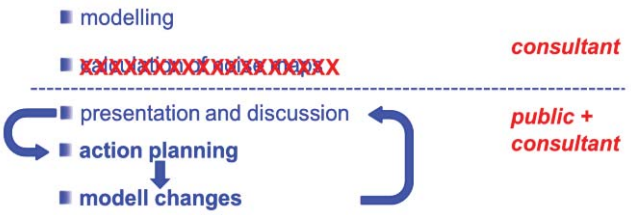


Figure 2: New approach to evaluate measures

Experts can use the software tool to quantitatively check given measurements regarding the noise source (such as traffic volumes, HGV percentage, speed limits , road surface). The impact of reduction on a source can also be identified in conflict areas with multiple sound sources. Within a discussion the focal points of noise can be identified even with new measures applied and further suggestions can be made.

For those assessments no recalculations in the common way are necessary, the results can be visualized and analysed within seconds. By this, the impacts of a mitigation measure can be discussed and multiple variations of measures can be compared within a single meeting.

Basics

Calculations

The input data for further steps needs a 3D model which is basically identical to existing models e.g. used for noise mapping. Basic calculations are also executed by a common noise prediction software (in this case IMMI) using a specialized export for further processing.

Those models contain terrain information and characteristics (dams, cuttings, embankments, and troughs, mounds, hilly / flat profile), reflection properties of buildings and noise barriers as well as the geometric parameters (location and width) of all relevant roads. The detailed information of the streets (traffic volumes, speed limits, HGV percentage, road surfaces) should also be included in the model, although these parameters can be varied later.

Changes in Emissions / Varying input data

All noise source related parameters can freely be chosen, e.g. for the RLS-90 (the official German calculation method) the amount of traffic, the HGV percentage, the speed limit and the road surface.

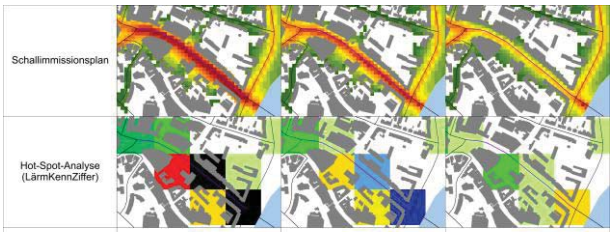
Since the software can also implement other emission models sensitive to further parameters (e.g. based on “TraNECaM" [Traffic Noise Emission Calculation Model]), measures at the vehicle fleet can be analyzed. Thus the impact of electric vehicles, low-noise tires or improvements in traffic flow can be displayed.

Besides the possibility to change parameters on single roads segments, a complete change of the traffic situation can be calculated. If the traffic related input is provided in a compatible format (ESRI shape file) by traffic engineers or authorities, it can quickly be loaded into the software to visualize and evaluate changes.

Representation

The results of all calculations can be shown in the common form of a noise map or in form of a table with the number of people exposed to noise. There is also a presentation of the façade levels, a hot spot analysis and a difference map showing the differences of noise levels between different scenarios. Adapted to the target group it is possible to show different colour scales to increase the comprehensibility of the pictures.

In addition to the calculation of the total immission, the depiction of the impact of an individual noise source (road section, rail route) is possible. Besides this, for any grid point or façade receiver point it is possible to analyze which noise emitter is contributing to the total noise level. Thus the most relevant source of noise is quickly identified.



Betroffene Anwohner	ohne Maßnahmen	Maßnahmenpaket 1	Maßnahmenpaket 2
> 55 dB(A)	414	392 (-18)	354 (-38)
> 60 dB(A)	242	222 (-20)	157 (-65)
> 65 dB(A)	79	0 (-79)	0 (0)

Figure 3: Examples for noise mitigation measures; noise map, hot spot analysis, people affected by noise

The figure above shows the improvement to a street which is highly exposed to noise. Using hot spot analysis an area with high noise levels and a high number of people affected was identified. The effects of changing parameters of the road or even multiple combinations of measures can be shown within seconds. Changes are not only shown in the noise map but also in the number of people affected and an updated hot spot analysis.

Depending on the parameters given to the software an even more detailed analysis can be carried out according to the given situation. These can not only contain analysis of costs (prices for new road surface or single measures given), a basic cost-benefit-analysis but also a detailed analysis of effects as real estate values, changes in tax income for the municipality or effects of noise annoyance.

Implementation

Web Tool

As part of a research project for the German Federal Environmental Agency (UBA) a tool was developed on the given basics to show an example of improved noise action planning. The web based tool should enable people to evaluate as well single measures as multiple measures. The main road parameters (as stated above) at all streets should be freely selectable. In addition collections of measures (e.g. from a noise action plan) can be suggested as scenarios to the users.

The users of this web tool could be not only consultants and people from local authorities but also the public in general if used in public participation.

Next to the noise maps of the current and the planned situation also a difference map and statistical data is shown. The statistics basing on the results of the façade calculations show the percentage of people affected by noise (heavy annoyed according to VDI 3722-2) and a calculation of real estate values and change in tax income for the municipality. These calculations are based on basics stated in the project “Silent City” of the UBA [1].

The presentation was optimized based on suggestions given by the HafenCity University earlier in the research project [2]. The colors shown in the maps are also based on the results of their study, taking problems of Color Blind people into account.

Access to the web tool will be published at our company website [3] within the next months.

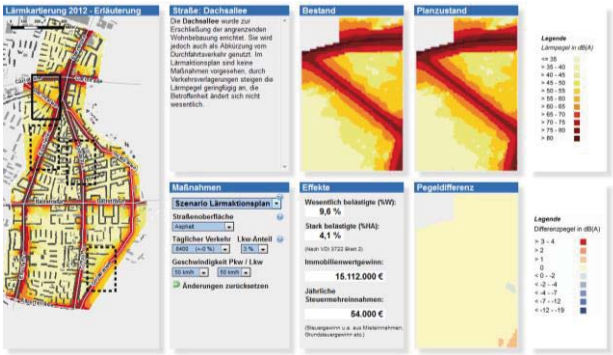


Figure 4: Overview for the web tool; noise maps (before and after), difference map, measures and effects

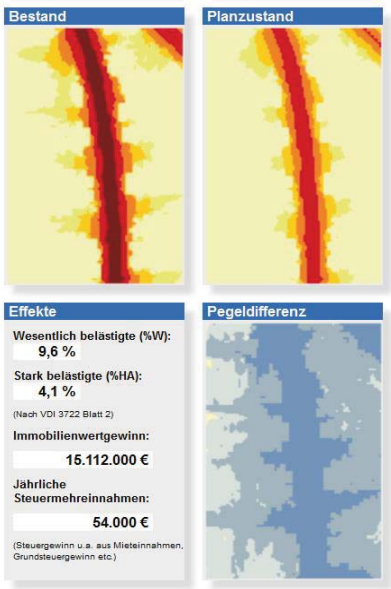


Figure 5: Effects of a mitigation measure in detail (buildings and roads not shown)

Desktop Tool

The basics are also implemented in a desktop tool to enable more powerful calculations and better interaction with the user. This tool is aimed to be used by consultants only, as various limitations have to be considered. As measures are always limited to the parameters of the source itself, other measures like noise barriers, ridges or changes of the street geometry may not be forgotten as possible solutions.

Used in discussions with local authorities consultants can quickly answer questions to the effectiveness of measures discussed, also in combination with other measures at the same source or in conflict areas with multiple sources involved.

The software has already been used in a German city with about 150.000 inhabitants. The model contained 2.000 separate noise sources (roads) on which measures could be chosen, the results for an area of over 30 km² and more than 250.000 façade receiver points are still available within a few seconds. Hot spot analysis supports consultants and local authorities in finding the conflict areas. In addition to this, façade receiver points can be displayed and analyzed to get more detailed information.

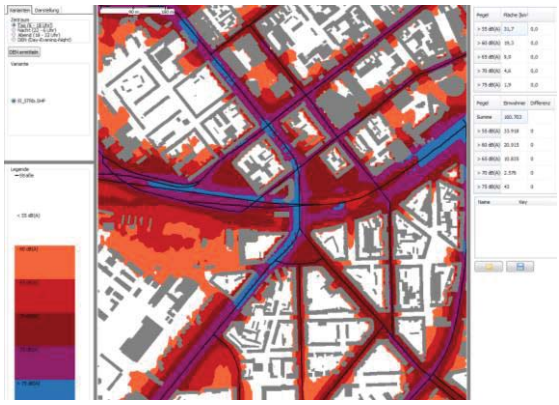


Figure 6: Desktop tool for use in noise action planning, view of noise map and statistics

Conclusions

The main issue of the Environmental Noise Directive (END) is not just to inform about the environmental noise. The main task of the END is to reduce the noise load for the residents significantly. Therefore it is necessary to involve the public effectively. This participation is heavily supported by the presented decision tool, but also in other discussions about noise mitigation measures the tool can help to improve decisions.

By the shown tool we can ensure a

- fast identification of relevant sources,
- fast identification of necessary measures and a
- “real time” evaluation of noise mitigation measures.

As the effects of proposals of different participants of a discussion can be visualized and quantified in their effects within seconds we can get to an active discussion and an iterative improvement of measures.

Outlook

Although more than just basic features have been implemented, the extension of the software is ongoing as new situations may need new methods of evaluation. For the future it is planned mainly to improve cost-benefit-analysis and to integrate an automated analysis to find the best measures with given restraints. The developed framework could also be used to create “dynamic noise maps” changing by a given parameter (noise measurement, traffic count) or visualize different aspects related to the calculated noise propagation.

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[3] Reference to LÄRMKONTOR homepage:
`http://www.laermkontor.de`