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Decision support system for Action Planning in the framework of the European Noise Directive

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The European Noise Directive (END) requires assessment of noise exposures as well as the formulation of Action Plans for the reduction of the number of people harmfully affected by environmental noise. TNO is developing a decision support system for noise mitigating measures. The proof of concept of such a system for road noise is presented here. On the basis of a detailed noise map, for each road segment an indication is given for the amount of negative effect (e.g. number of people being highly annoyed) per meter it is causing. On the basis of the characteristics of the road segment, the system suggests possible noise mitigation measures. The effect of the measure chosen by the user, such as the application of silent road surface types or lowering speed limits, can be interactively explored with the system. It directly shows the updated detailed noise contour maps as well as indicators describing the impact after a measure has been applied though the interactive interface.

1 Introduction

The European Parliament and Council adopted the Environmental Noise Directive (END) [1] in 2002 for dealing with the noise problem across the European Union. Some of its main objectives are to draw up "strategic noise maps" and to formulate action plans to reduce noise levels where necessary. One of the projects started at EU level to meet these objectives is the EU Sixth Framework Program project Quiet City Transport (QCity). The objectives of QCity are to propose measures and solutions concerning noise in cities that can practically be integrated in the action plans that these cities have to draw up as a consequence of the END

In the framework of QCity, TNO is currently developing a decision support system for (evaluation of) noise abatement measures, focusing initially on road traffic noise. The decision support system is being implemented in TNO's spatial planning tool Urban Strategy. This interactive spatial planning tool enables users to evaluate the effect of noise abatement measures real time. The decision support system helps planners to localize the noise sources that have most impact and to think of noise abatement measures that are most (cost) effective. This decision support system is valid for any city in general, but here it has been applied to the city of Amsterdam (The Netherlands) for road traffic noise. Using a road traffic noise map of the city of Amsterdam the impact of each road traffic noise source is quantified. The number of highly annoyed people per meter is calculated for each road segment. Based on this noise impact quantification, the decision support system should then suggest a short list with the most (cost) effective noise abatement measures. The user/planner can then select a measure and calculate its effect real time.

This work is being carried out in the framework of the EU FP6 project QCity.

2 Rating environmental noise

To evaluate the necessity of noise abatement measures and to determine the improvement that may be obtained with noise abatement measures, it is necessary to have a system to rate environmental noise. Such a rating system based on noise maps has been presented by Miedema et al. [2]. One of the four indicators, which together constitute the environmental noise rating system, is the percentage highly annoyed people (*%HA*).

The *%HA* is defined as the percentage of responses exceeding the cutoff of 72 on a 0-100 scale of annoyance, with 0 corresponding to no noise annoyance, and 100 to corresponding to an extreme noise annoyance. It can be calculated for various noise sources (aircraft, road traffic, railways. For example for road traffic noise, the *%HA* as a function of L_{den} may be expressed as [3]

$$\%HA = 9.868\times10^{-4}\,(L_{den} - 42)^3 - 1.436\times10^{-2}\,(L_{den} - 42)^2 + 0.5118\,(L_{den} - 42).$$

The numerical coefficients were determined in a fit to data from noise annoyance studies for road traffic noise. Here, as a noise exposure metric, the sound pressure level L_{den} has been used. It is defined in terms of the sound pressure levels during daytime, evening, and night. Its precise definition is

$$L_{den} = 10\lg\left[(12/24)10^{LD/10} + (4/24)10^{(LE+5)/10} + (8/24)10^{(LN+10)/10}\right],$$

where *LD*, *LE*, and *LN* are the A-weighted equivalent sound pressure levels for the day (7-19h), evening (19-23h), and night (23-7h) respectively determined over the year.

Borst & Miedema [4] showed how this indicator can be used to calculate the number of highly annoyed people, and how this indicator can be used to compare different noise abatement strategies.

3 Concept of the decision support system

The decision support system, that helps planners to localize noise sources that have most impact and to think of noise abatement measures that are most (cost) effective, basically consists of the following five steps:

1. quantification of the impact of each noise source, for road noise e.g. the number of highly annoyed per meter;
2. the user selects the noise sources to which noise abatement measures are applied;

3. decision support system suggests a shortlist of effective noise abatement measures;
4. the user selects a noise abatement measure;
5. the effect of the selected noise abatement measure is calculated interactively.

The first, third and the fifth step are the most important ones in the construction of the decision support system. These three steps will be discussed in more detail in the following sections

3.1 Quantification of the impact of noise sources

Here we elaborate on the quantification of the impact of noise sources. In particular we will consider the number of highly annoyed (*HA*) people, see also [3], as a result of road traffic noise as the appropriate noise impact indicator; and then we will determine the *HA* per road segment. Here the road segments are identified as the noise sources. To be more specific, the quantification scheme for the impact of noise sources is as follows:

1. define calculation points (receptors) on each façade of each dwelling;
2. calculate the noise load on each receptor, and store the noise load contribution per road segment;
3. for each dwelling, determine the receptor with the highest noise load;
4. calculate the percentage of highly annoyed (*%HA*) people for each dwelling, using the receptor noise load values;
5. assign the contribution to *HA* to each road segment (weighted by the noise energy contribution of the road segments);
6. sum the *HA* contributions for each road segment.

In order to quantify the impact of road traffic, all roads are split up in 50 meter segments. For each road segment one can calculate the number of highly annoyed people resulting from the noise contribution of that specific road segment. Once the noise impact (in this case *HA*) is known for each noise source, the decision support system will suggest a shortlist with the most (cost) effective noise abatement measures. This is discussed in more detail in the following section.

We remark that the above quantification scheme can in principle be generalized to other noise impact indicators.

3.2 Determination of noise abatement measures

The user can select the road segments to apply noise abatement measures onto.

In the QCity project, a list of possible noise abatements measures in made. These noise abatement measures will be implemented in a database describing the measures, calculation rules for possible impacts, as well as boundary conditions for implementation.

The decision support system will determine which noise abatement measures are feasible and most effective and present a short list to the user. For this purpose all road attributes (such as traffic intensity, traffic speed, size of the road, distance of road to buildings, types of buildings along road), of the specific road segments with a large *HA*, are evaluated. In this way it is possible to figure out automatically which measures are feasible.

3.3 Interactive noise maps

The effect of the selected noise abatement measure can be calculated with Urban Strategy’s interactive noise maps. The state-of-the-art models that constitute Urban Strategy are able to perform calculations very fast so that action planning can be done interactively. The effects of various noise measures (e.g. lowering speed limits, silent road surface types) can be explored interactively with the system. The software is constructed in a modular way such that it can be linked to a traffic model, so that the effect of traffic measures can also be evaluated. Also the used noise model can easily be replaced by other detailed noise models.

Noise impact indicators are an effective aid to compare various noise abatement scenarios [4]. Directly after a noise abatement measure has been applied through the interactive interface the updated noise impact indicators (e.g. annoyance) as well as detailed noise contour maps are shown.

For further details about the interactive noise maps we refer to Borst et al. [5]

4 Results for Amsterdam

Calculations described here have been performed for and commissioned by the city of Amsterdam. The results of this calculation are depicted in Fig. 1 for a selected part of the city centre of Amsterdam.

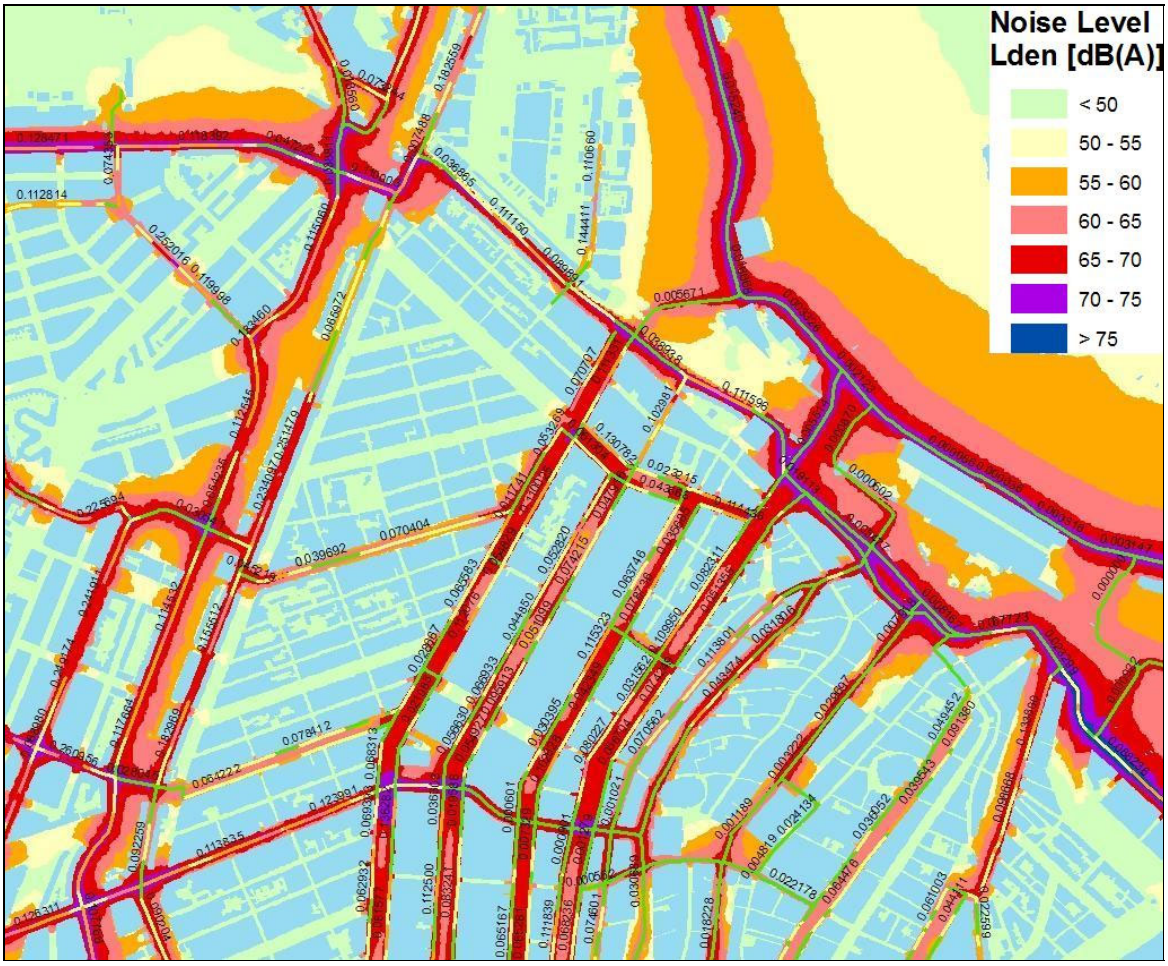

Fig. 1 A zoomed in road traffic noise map for the city of Amsterdam. The values for the noise load, L_{den} in dB(A), are represented by the various colors. The numbers indicate the number of *HA* per meter for the specific road segment.

Fig. 1 shows a road traffic noise map for a selected part of the city centre of Amsterdam. The colors represent the road traffic noise levels, L_{den} in dB(A). The number of highly annoyed people (*HA*) per meter for various road segments is indicated by the numbers along the roads. Road segments with a high noise level do not necessarily correspond with a large number of *HA* per meter. Most likely this is caused by be the small number of dwellings close to those roads or a small number of inhabitants per dwelling.

Similar to the previous figure, a map for Amsterdam indicating the number of highly annoyed people (*HA*) per meter for various roads is shown in Fig. 2 The values for the number of *HA* per meter are indicated by the various colors, see legend. We note that the number of *HA* per meter for the orbital motorway A10 is small at most places (green colored), although the noise level of the orbital motorway is quite large in fact. This is most likely related to the relatively small number of dwellings near the orbital motorway, a small number of inhabitants per dwelling or the presence of noise abatement measures. Fig. 2 also shows that the number of *HA* per meter is large especially in neighborhoods around the city centre.

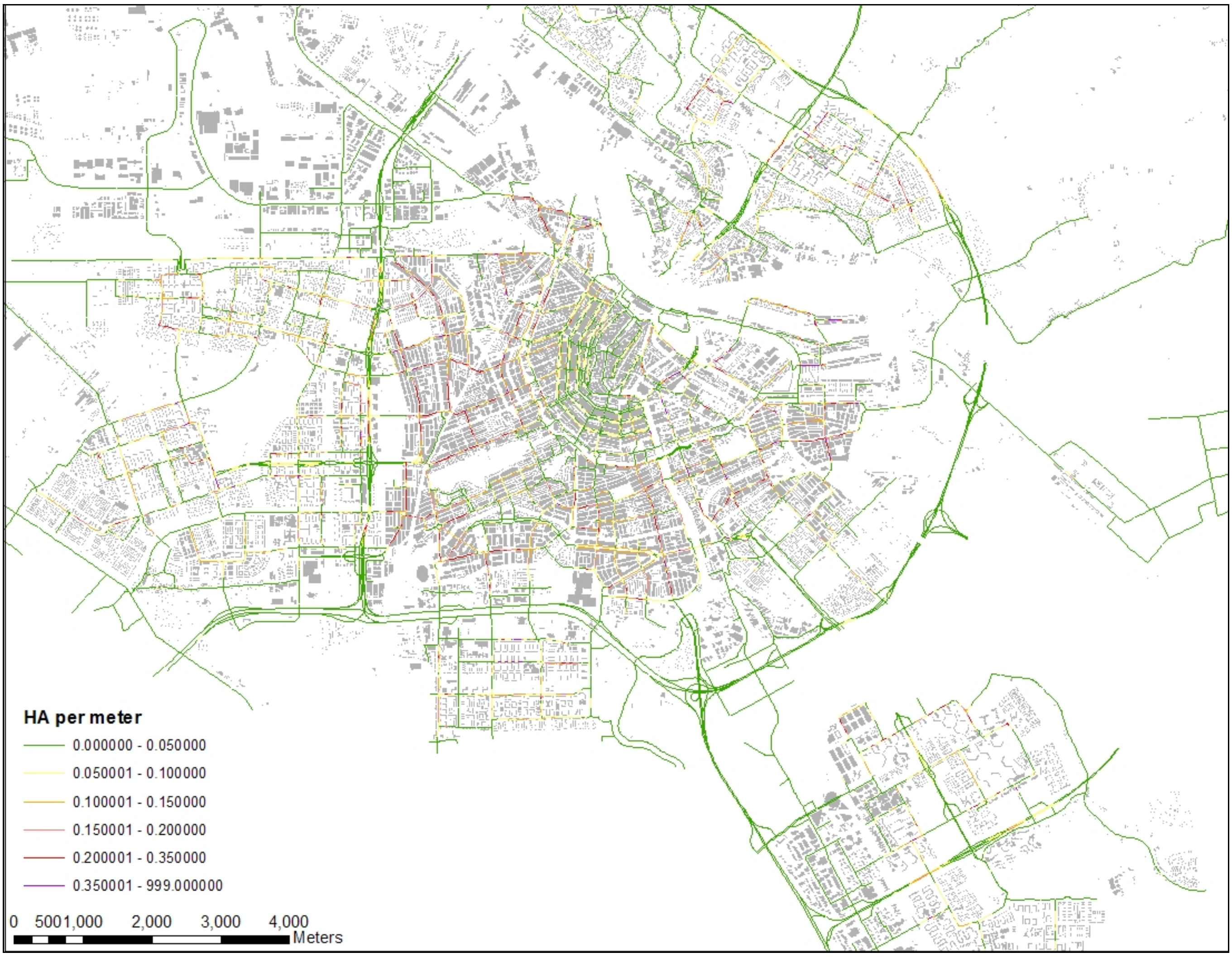

Fig. 2 Road traffic noise impact map of Amsterdam. The various colors indicate the number of *HA* per meter for the specific road segment, see the legend.

5 Conclusions

A decision support system for evaluation of noise abatement measures is currently being developed and implemented. The decision support system supports planners to localize noise sources that have most impact and to think of noise abatement measures that are most effective. The system will be useful in action planning in the framework of the European Noise Directive (END).

In contrast of focusing on places in a city where relatively many people are harmfully affected by high noise levels ('hot spots') the decision support system focuses on noise sources that are responsible for a large number of people harmfully affected by noise. Doing so, the decision support system points towards those noise sources where lowering noise emissions have most effect on the impact indicator used. The noise impact indicator we use for this paper is the number of highly annoyed people (*HA*).

First results for the quantification of the impact of road traffic noise sources in the case of the city of Amsterdam are presented. In particular, the number of highly annoyed per meter for various road segments has been calculated and displayed in a map.

This map provides insight in those areas where noise reduction has most effect on the number of people being highly annoyed.

In the near future also other noise sources than road traffic (rail and tram) can be implemented. Also other impact indicators than *HA* could be used. An important step would be to extend the decision support system in such a way that it can also consider overall noise measures such as the application of silent tires or the introduction of car free city zones.

References

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