

Using Traffic Models as a Tool When Creating Noise Maps

-Methods used in the EU-project QCity

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Abstract

In this working paper we describe a method to adapt outputs of a macroscopic transport model to a noise mapping software. The interface has been developed as a part of a study in the EU-project QCity where noise effects of traffic control measures are analysed. A noise map of a base scenario where no policy has been applied is presented. Moreover a sensitivity analysis of speed data input is made, where speed limits is used instead of modelled speed. It shows that speed limits gives up to 3 dB higher noise levels than use of modelled speed. We believe this is an aspect to consider when official noise maps and action plans are created, as official speed restrictions are often used instead of actual speed.

1 Introduction

Traffic noise is an environmental concern that has become relevant recent years as many people in industrial countries suffer from unacceptable noise levels. The awareness of the problem has increased and the EU Environmental Noise Directive 2002/49/EC (END) requires that noise maps and action plans be developed for larger agglomerations and major roads, railways and civil airports.

The aim of the EU project QCity is to develop an integrated technology infrastructure for efficient control of road and rail ambient noise by considering the attenuation of noise creation at source at both vehicle/infrastructure levels. A major objective is to provide municipalities with tools to establish noise maps and action plans in accordance with the END and to provide them with a broad range of validated technical solutions for the specific hot-spot problem they encounter in their specific city.

Noise reduction action plans need to take into account a wide range of different options to reduce noise. In order to relate technical improvements investigated in the QCity project to other means of noise reduction, the Royal Institute of Technology participates in a subproject to calculate such effects using traffic models and noise mapping software.

In selected study areas in Stockholm, different scenarios with respect to traffic control strategies are analysed and compared. The changes in flows that occur for different control scenarios are used as input to create related noise maps. Restricting car traffic to specific

links, restricting speed and economic restrictions by area or link, are scenarios studied. General policies to reduce car traffic such as improved public transport and tolls are studied additionally. Analysis of these measures is now an ongoing work.

In this working paper we describe the methods developed to adapt the transport model outputs to a noise mapping software. The interface has been developed in cooperation with experienced expert acousticians at Acoustic Control, Sweden, coordinators of the QCity project. We illustrate a noise map of a base scenario where no measure has been applied. A discussion on which speed data to use for noise mapping, modelled speed or speed limit, is presented additionally.

2 Method

Traffic data required to create a noise map are volume, speed and share of heavy vehicles. To follow the END these data are needed for day, evening and night time periods. In the EU-project IMAGINE (Improved Methods for the Assessment of the Generic Impact of Noise in the Environment), the suitability of traffic models for noise modelling was considered (IMAGINE report, 2005). The conclusions were in short that “There is no superior type of traffic model to deliver input for traffic noise models. Depending on the study area (e.g. major roads, or agglomerations), several traffic model types are capable to deliver the required output.” The project moreover points out that choice of model also depends on models currently in use, availability of data and the measures that have to be assessed. In the QCity project therefore different types of models are used in different applications.

2.1 Transport model used

When studying traffic control measures and mode shift policies we use the transportation modelling system Sampers (Beser and Algiers 2002) developed in Sweden. It contains a multimodal travel demand model system applying discrete choice models of the nested logit type (Ben-Akiva, Lerman 1985). Moreover it is integrated with the analysis package Emme/2 (Inro, Canada) where route choice is modelled by the concept of network equilibrium (Ortúzar, Willumsen 1990). The Emme/2 system is a macroscopic model where a region to be analysed is described by zones, links and nodes. Zones are areas that generate or attract trips representing e.g. dwellings and working sites, whereas links and nodes make up the traffic network. The most detailed results are vehicle flows per category per link for different time periods, and transit loads for the same periods.

Demand model parameters are estimated on the National Swedish Travel Survey 1994-2000, and calibrated for the year 2001. In this application, the road and public transport network for year 2005 is used. A two-way street is represented by two links with reversed directions. Heavy vehicles are represented by trucks with a fixed demand matrix and by buses in the public transport system.

Periods modelled are the time intervals 7 a.m. to 9 a.m. and 9 a.m. to 16 p.m., representing morning peak traffic and off peak traffic. Outputs of a simulation represent traffic conditions of an average hour of each time period. Figure 1 illustrates a part of Stockholm County and the auto volumes for a morning peak hour in our base scenario. The study area Järva is encircled in blue.

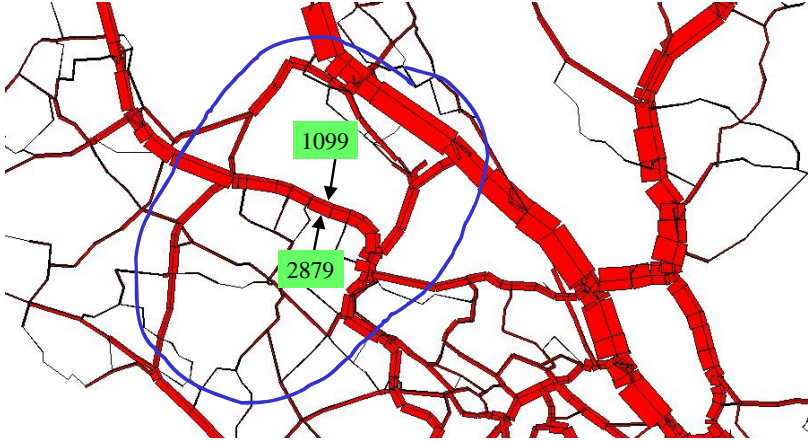


Figure 1: Automobile traffic volumes of morning peak hour (base scenario).

When creating noise maps it is common to use official speed limits as input. However the assignment model in Sampers captures the reduction in speed due to capacity constraints. This is exemplified in Figure 2 where the red marked road has a speed limit of 70 km/h but the modelled speed is lower (volumes shown in Figure 1.) As a policy measure may have effect on speeds we believe it is important to use modelled speed instead of fixed speed, also since speed is an important noise factor. A sensitivity analysis has been made showing the difference in using speed limit instead of modelled speed. The results are found in chapter 3.

The uncertainty of speeds (and flows) modelled by the assignment model may be an issue when using the model to provide input to noise calculations. For this application, we aim at describing effects of different policies rather than the actual current situation, and therefore the precision of describing the current situation is somewhat less important.



Figure 2: Modelled speed in morning peak hour (Base scenario).

2.2 Adapting Traffic Forecasts to Noise Mapping Software

The noise mapping software used is CadnaA (developed by Datakustik GmbH, Munich), which is a commercially available software. In order to use the outputs of Sampers as input to CadnaA we have created an interface. It handles both differences in network representation and aggregation levels in traffic data.

2.2.1 Geographical correspondence

In CadnaA shape files with related data are used as input to describe the road network. However the traffic model network has a more simple representation and only main roads are modelled. This is illustrated in Figure 3, showing main roads and local streets of the study area Järva to the left and its model correspondence in Emme/2 in the middle. Rightmost is an overlapping picture of the Emme/2 network and the main roads in the shape file.

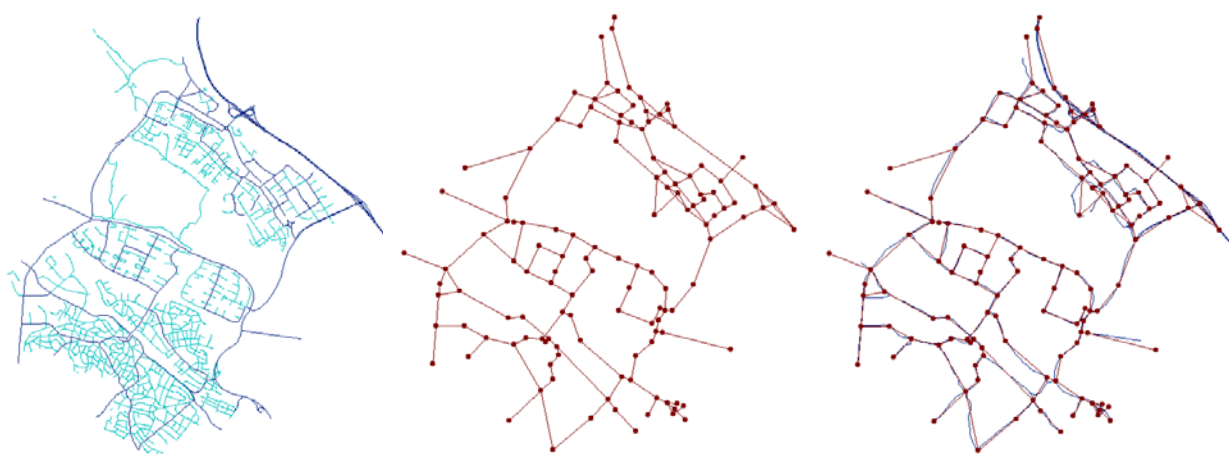


Figure 3: Main roads and local streets and model network of Järva.

To use the model network as input instead would not be a suitable solution as e.g. height contour lines and location of buildings are considered when noise is calculated. Consequently the two networks have to be matched. This is not uncomplicated. A lot of research has been made to develop methods to match spatial data sets e.g. Walter and Fritsch (1999) have developed a method with a statistical approach. Though to implement and apply such a method in these studies was considered too time consuming, therefore a manual method was used to relate the model links to the roads represented in the shape file. (From now on we will use roads as a reference to the network used in CadnaA and links as a reference to the Emme/2 network). Figure 4 and Table 1 illustrates an example of how the match was made. (Note that a link is represented by a from node and a to node and index r indicates the return link.)

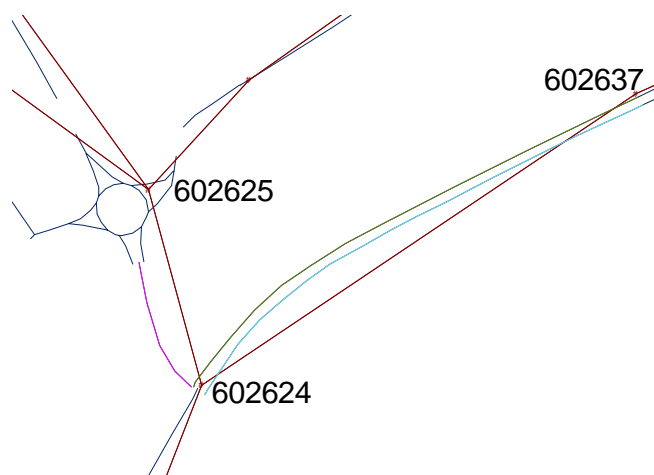


Figure 4: Network example.

Table 1: Example link/road relation

	Road ID	Fnode	Tnode	Fnode_r	Tnode_r
Green road	1	602637	602624	0	0
Turquoise road	2	602624	602637	0	0
Cerise road	3	602624	602625	602625	602624

Since the CadnaA network is more detailed than the Emme/2 network a few junctions emerged where there were no straightforward relation between the networks. In these cases characteristics such as speed limit of roads and links in the entire intersection were adopted. Road lines describing mid circles in roundabouts, seen for example in Figure 4, can not be related to any link and they are therefore excluded when noise maps are created.

2.2.2 Traffic data interface

To follow the END when creating noise maps, traffic data is required for the time periods day, evening and night. However as Sampers like most traffic models only models daytime traffic we calculate noise levels of an average day and do not include the late hours. In our studies of effects of different measures we consider this being adequate.

To calculate day traffic data of a road, peak hour and off peak our results per link are stored, see Table 2.

Table 2: Stored model outputs per link and time period simulated

Automobile traffic	Public Transport
Traffic volume of cars [Vehicles per hour]	Traffic volume [Vehicles per hour]
Traffic volume of trucks [Vehicles per hour]	Speed [Kilometres per hour]
Speed [Kilometres per hour]	

Using the road/link relation created and the definitions below we compute volume, speed and share of heavy vehicles of road i using the formulas 1, 2 and 3. Note that the average speed of a road is calculated by weighting the link and return link speed by their traffic volumes. This is due to the fact that for e.g. morning peak hours traffic volumes are high on links with direction towards the centre of Stockholm and low on links going out of Stockholm. Thus equal weights would not give results reflecting this dynamics. Here we only consider road traffic, which means that for public transport only buses are considered.

V_i Average traffic volume on road i [vehicles per hour]

S_i Average speed on road i [kilometres per hour]

SHW_i Share of heavy vehicles on road i [percent]

$$V_i = V_{c,i} + V_{cr,i} + V_{t,i} + V_{tr,i} + V_{pt,i} + V_{ptr,i} \quad (1)$$

$$S_i = \frac{(V_{c,i} + V_{t,i}) \cdot S_{ct,i} + (V_{cr,i} + V_{tr,i}) \cdot S_{ctr,i} + V_{pt,i} \cdot S_{pt,i} + V_{ptr,i} \cdot S_{ptr,i}}{V_i} \quad (2)$$

$$SHW_i = \frac{V_{t,i} + V_{tr,i} + V_{pt,i} + V_{ptr,i}}{V_i} \cdot 100 \quad (3)$$

where

$V_{c,i}$ Car volume of the link related to road i [vehicles per hour]

$V_{cr,i}$ Car volume of the return link related to road i [vehicles per hour]

$V_{t,i}$ Truck volume of the link related to road i [vehicles per hour]

$V_{tr,i}$ Truck volume of the return link related to road i [vehicles per hour]

$V_{pt,i}$ Public Transport volume of the link related to road i [vehicles per hour]

$V_{ptr,i}$ Public Transport volume of the return link related to road i [vehicles per hour]

$S_{ct,i}$ Car and truck speed of the link related to road i [kilometres per hour]

$S_{ctr,i}$ Car and truck speed of the return link related to road i [kilometres per hour]

$S_{pt,i}$ Public transport speed of the link related to road i [kilometres per hour]

$S_{ptr,i}$ Public transport speed of the return link related to road i [kilometres per hour]

In a first step we calculate traffic data for peak traffic and off-peak traffic separately, moreover we weight together the results to obtain values representing an average daytime hour. As the time periods simulated represents traffic conditions between 07 - 09 and 09 - 16 and in the END the day period is defined as 06 - 18, we use the weights 4 hours peak traffic and 8 hours off-peak traffic respectively. Using this relation and indexes P and OP , representing peak hour and off-peak hour results, we calculate day traffic data using the formulas 4, 5, and 6.

$$V_{DAY,i} = \frac{4V_{P,i} + 8V_{OP,i}}{12} \quad (4)$$

$$S_{DAY,i} = \frac{4S_{P,i} + 8S_{OP,i}}{12} \quad (5)$$

$$SHW_{DAY,i} = \frac{4(V_{Pt,i} + V_{Ptr,i} + V_{Ppt,i} + V_{Pptr,i}) + 8(V_{OPt,i} + V_{OPtr,i} + V_{OPpt,i} + V_{OPptr,i})}{4V_{P,i} + 8V_{OP,i}} \cdot 100 \quad (6)$$

3 Results

In addition to traffic data calculated, a digital terrain model is applied in CadnaA when noise maps are created. The model includes contour lines defining the height along the line, locations of larger wooded areas, lake shorelines, locations of buildings and screens as well as their height. The software automatically manages the effects of ground absorption, screening, reflections etc. according to the official Nordic prediction method for road traffic noise (Nordisk beräkningsmodell rev. 1996).

Local streets that are not modelled in the traffic model network are not considered in the noise map calculations. Generally template traffic data are applied on local streets but as we analyse and compare effects of different measures, streets with fixed data would not give any tribute to the studies. However if a policy has large effects on traffic, a method to capture the noise effect also on local streets is to apply adjusted template values.

3.1 Noise map of base scenario

Using the methods described a noise map of the base scenario in study area Järva has been created by Acoustic Control. The map is shown in Figure 5. It illustrates sound pressure levels calculated for daytime traffic on main roads (L_{DAY}) where the grid has a receiver spacing of 10 by 10 meter and a receiver height of 4 meter. All roads are set to the ground level except for a bridge in the centre of Järva. Note that neither railroad traffic nor local streets are included.

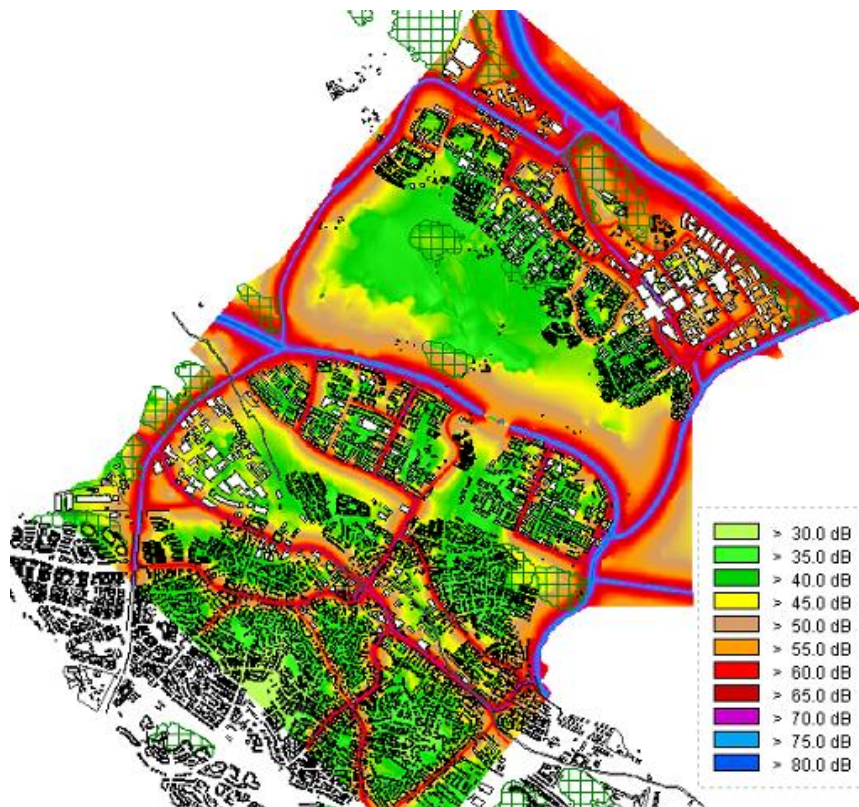


Figure 5: Noise map of base scenario in Järva, Stockholm (L_{DAY})

3.2 Sensitivity analysis of traffic speed

To examine the effect of using officially allowed speed instead of modelled speed in noise mapping; a sensitivity analysis of this aspect was made. A scenario was created where each road was given the speed limit of the road type that the related links were modelled to simulate. A noise map was created where all inputs except speed data were identical with the base scenario. Figure 6 illustrates the differences between this map and the noise map of the base scenario. It shows that use of speed limits gives higher noise levels than use of modelled speed. The largest difference is approximately 3 dB. Main distinctions appear as expected close to high dense roads where the models capture the reduction in speed due to capacity constraints. This indicates the magnitude of dB levels that are missed out in studies of traffic control measures if fixed speed is used.

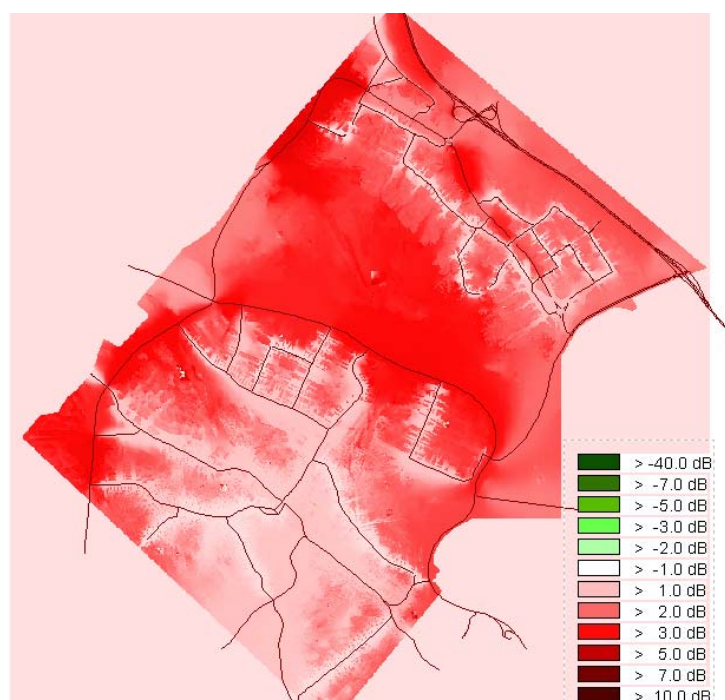


Figure 6: Difference in sound pressure level using speed limit instead of modelled speed.

4 Discussion and Conclusions

When adapting traffic models to noise mapping software one may discuss to what extent the applied traffic model delivers reliable outputs. If the aim is to create a noise map of a real life situation extra caution should be taken. Though in our studies of effects of traffic control measures it is the difference in noise between different scenarios that is of interested and not the exact levels. Thus most important is how well the model can model the policy in question. Sampers is a well established forecasting software and is used by public authorities and consultants in Sweden. Traffic control studies have been made in many projects and the model is considered trustworthy in this aspect.

Our sensitivity analysis gives an indication of the difference in using allowed speed limits instead of actual speed. This aspect might be of interest when official noise maps and action plans are created, as noise levels is e.g. an important factor in decision of localisation of new buildings. This leads to the suggestion that effects of action plans should be related to the current situation rather than as absolute values resulting from model runs.

6 References

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