DELIVERABLE 2.4

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TITLE	Quiet City Transport
Subproject 2	Perception of Vehicle Noise Sources
Work Package 2.3	Evaluate Noise Mitigation Measures

Traffic control measures for vehicles: Basic Concepts

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TABLE OF CONTENTS

0 EXECUTIVE SUMMARY

0.1 OBJECTIVE OF THE DELIVERABLE

The objective of deliverable 2.4 is to describe the basic concepts of the methods to be used to evaluate noise mitigation measures related to traffic control. It gives an introduction to the concept of traffic forecasting and describes briefly the transport modelling system as well as the noise mapping software used in the studies. In addition it describes the interface between of the two modules developed.

0.2 STRATEGY USED AND/OR A DESCRIPTION OF THE METHODS (TECHNIQUES) USED WITH THE JUSTIFICATION THEREOF

Traffic is a result of people's choices. Where to travel, in what kind of mode, on which route and at what time, are all questions we answer when we make a journey. With traffic models you try to simulate these choices using people's values derived from actual behaviour in traffic. To evaluate effects of a change in the traffic system like a new road or introduction of tolls, traffic models are helpful tools. Consequently traffic forecasts are often used to support decision-makers when evaluating different solutions of current traffic problems or future scenarios.

The objective in work package 2.3.2 is to evaluate noise mitigation measures related to traffic control. Different scenarios will be analysed and compared using a traffic forecasting model and a noise mapping software. The changes in flows and speed that occur for different traffic control strategies will be 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 to be studied.

Although the project has a focus on “hot spots” and “quiet areas”, attention will also be paid to the whole urban area as different control measures often have system wide effects. We will use the Sampers transportation modelling system (Transek, Sweden) and its existing model modelling trips in an area including Stockholm County (illustrated in Figure 1 and Figure 2). Traffic control measures will be applied in sub areas of the model network. For these areas we create noise maps using the software CadnaA (Datakustik GmbH, Munich) and study the measures' impact on noise levels. In addition, accessibility, environmental and road safety effects can be analysed at a regional level.

Two study areas in Stockholm municipality have been selected, Järva and Södermalm. The first area represents a suburban region with road types varying from local streets to European highways and different forms of public transport such as buss and commuter train. The second area represents an urban environment in the centre of Stockholm. Figure 3 shows an orthographic photo of Stockholm municipality and the study areas encircled in white.

Figure 1 Sweden and the location of model area coloured in blue.

Figure 2 The model network shown with study areas encircled in red.

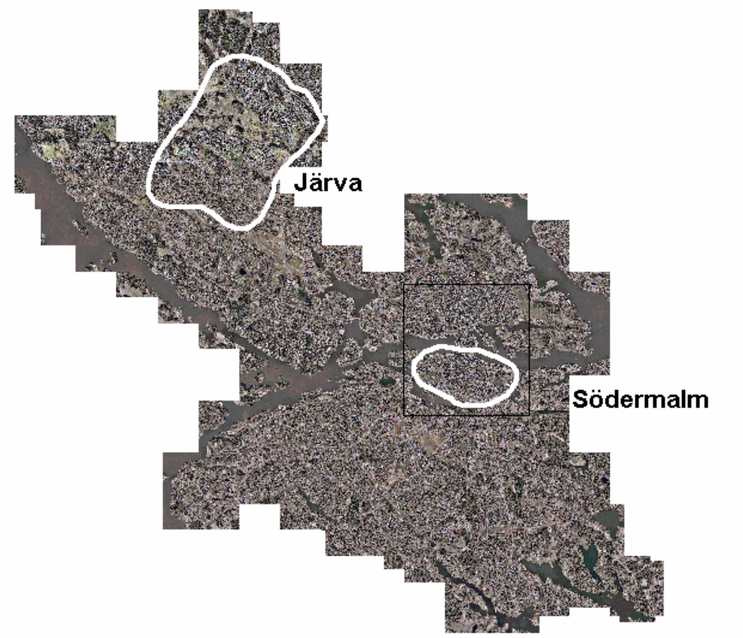

Figure 3 Orthographic photo of Stockholm Municipality. Study areas encircled in white and City centre marked by black square.

The Sampers system contains a multimodal travel demand model system, which is integrated with the analysis package Emme/2 (Inro, Canada). It 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 link for different time periods and transit loads for the same periods. The model structure is illustrated in Figure 4. Figure 5 illustrates a simulation result, the auto volume of morning peak hour traffic for our base scenario where no traffic control policy has been implemented (study areas encircled in blue).

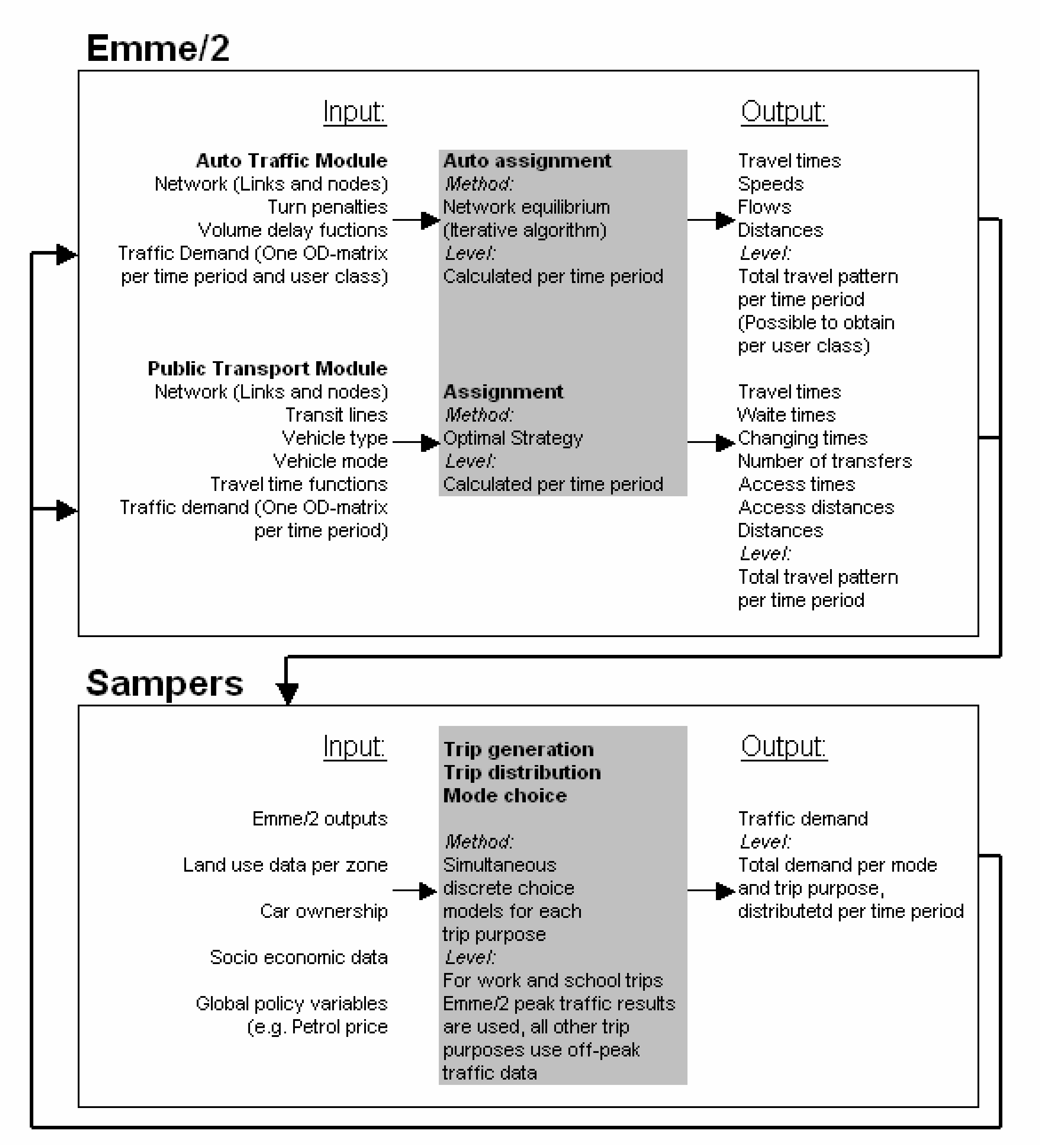

Figure 4 Structure of the transportation modelling system Sampers and its integration with Emme/2.

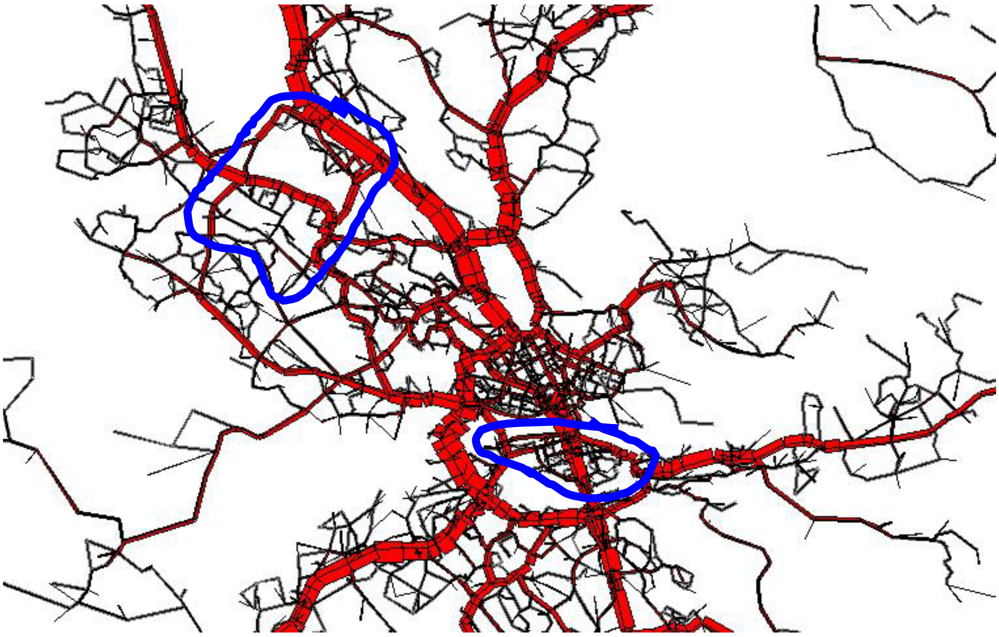

Figure 5 Average automobile traffic volumes of morning peak hour (base scenario).

The road network and public transit lines are modelled in Emme/2. When evaluating different traffic control policies as restricting car traffic to specific links and restricting speed, the package is used to introduce these changes in the origin model network. For example it is possible to restrict car traffic in an area by not allowing cars on the specific links, or reduce speed limits by changing volume delay functions. Note that all changes affect the whole travel pattern. If a strategy is to forbid car traffic on a link, this will force people who used to travel on the link to choose another route. However they may also change destination, mode or even cancel the trip, all depending on the change in accessibility due to the policy. An example is shown in Figure 6, where car traffic has been prohibited on the link marked by the arrow. The picture illustrates the change in auto volume that occurs relatively the base scenario in the study area Järva (green marks a decrease and red marks an increase).

Figure 6 Change in auto volume relatively the base scenario due to prohibition against car traffic on link (peak hour).

When studying economic restrictions we intend to analyse restrictions for heavy vehicles and introduce the concept of silent cars. Scenarios will be run where heavy traffic is prohibited on specific links and on links where we previously forbid car traffic, silent cars will be allowed. Other scenarios that may be modelled is to introduce tolls where silent cars do not need to pay the charge and introduce zones where noisy cars must pay high fees to enter.

In order to use the outputs of Sampers as input to the noise mapping software CadnaA we have to create an interface. First of all we have developed a manual method to relate the links of the model network to the roads described in the shape file used as input to CadnaA. The two networks of the study area Järva are illustrated in Figure 7 (the Emme/2 network in red and the main road shape file in blue). A key makes it possible to transfer simulation results to the data base file associated with the road shape file. For the study area Järva a link/road relation has been created and a key for the study area Södermalm is under construction.

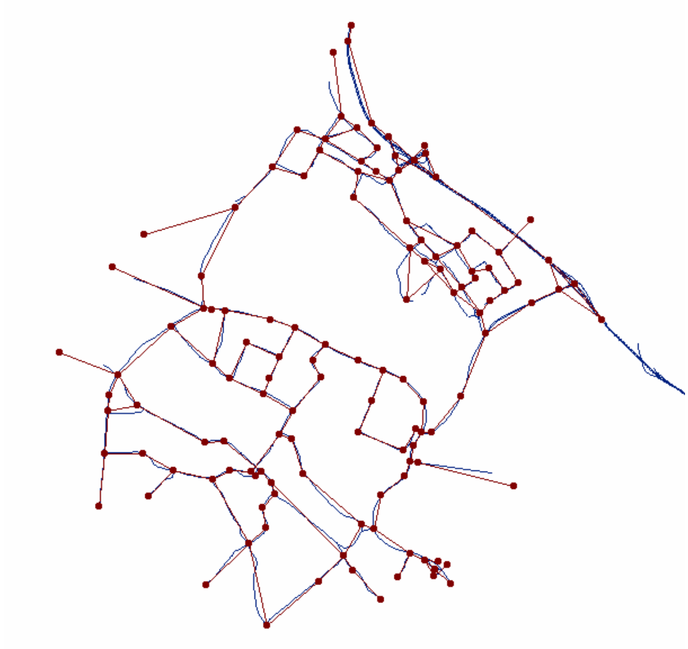

Figure 7 Emme/2 network and main roads.

Traffic data inputs in CadnaA are average speed, flow and share of heavy vehicles per road represented for the time periods day, evening and night. However as the simulation results of Sampers are not at the same aggregation level we have created a traffic data interface to recalculate the simulation outputs. The Sampers system models daytime traffic in two different periods, morning peak hour and off-peak hour and consequently the simulation results are weighted to obtain daytime inputs to CadnaA. In addition it is possible to make adjustments in Sampers to also model evening and nighttime traffic. For cases when there is an interest to study noise level impacts on local streets we have developed a method which makes it possible to study the impacts of a traffic control measure even though local streets are not represented in the Emme/2 network. However the method will only be relevant to use if a policy changes the number of car trips in a zone used in Sampers significantly.

Using the interface developed we have created a noise map of the base scenario in Järva, shown in Figure 8. The map 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.

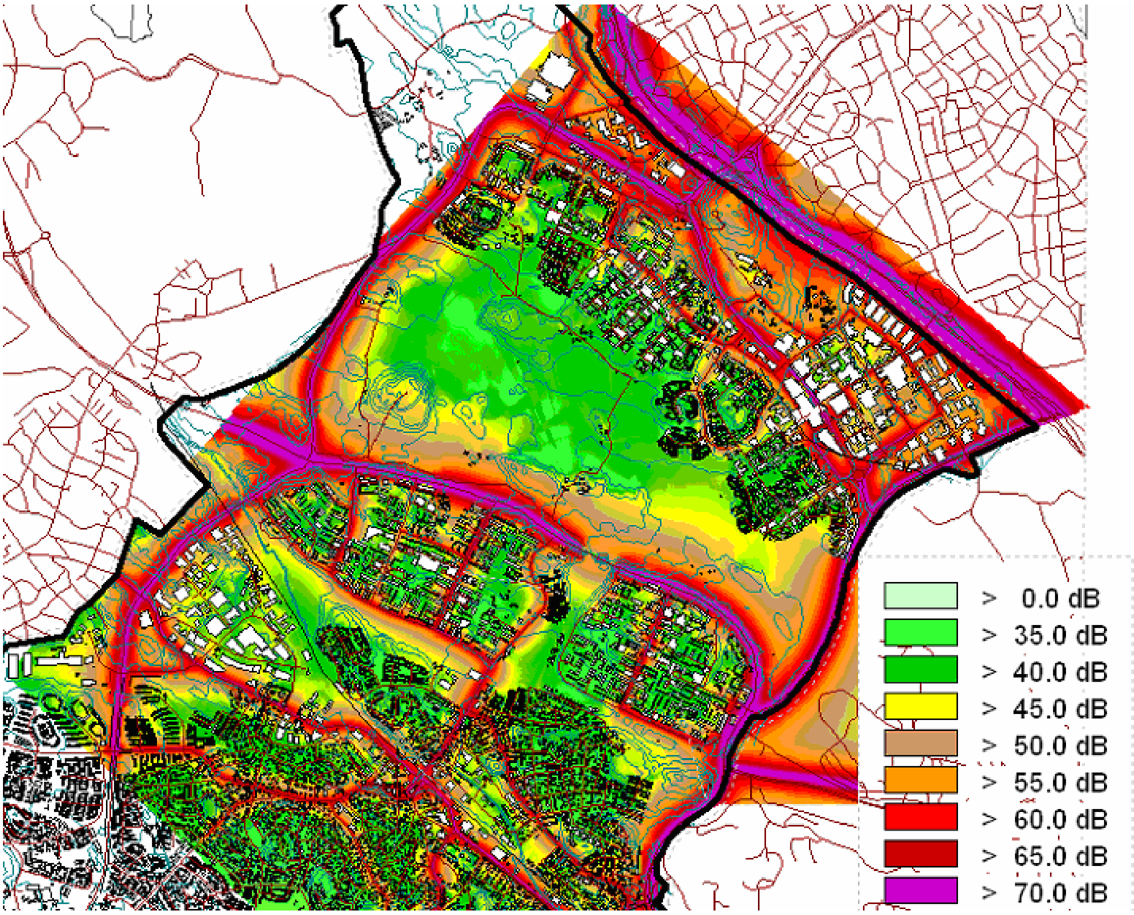

Figure 8 Noise map of base scenario in Järva, Stockholm (L_{Day}).

0.3 BACKGROUND INFO AVAILABLE AND THE INNOVATIVE ELEMENTS WHICH WERE DEVELOPED

Until now, the work has been to set up a Stockholm test site model environment and to develop necessary interfaces between the Stockholm forecasting model and the CadnaA noise mapping software. The final results of this task will be reported in a future deliverable

0.4 PROBLEMS ENCOUNTERED

During the model and interface development we have not encountered any major problems that have made us reconsider the overall approach of the studies.

0.5 PARTNERS INVOLVED AND THEIR CONTRIBUTION

Partners involved in WP 2.3.2 are the Royal Institute of Technology (KTH) and Acoustic Control (ACL). KTH handles the traffic modeling where as Acoustic Control will create noise maps with traffic data obtained from simulations. Moreover the interface between the two modules is developed using experience and expertise of both partners.

0.6 CONCLUSIONS

The basic concepts to use in work package 2.3.2 are clear. Different traffic control scenarios will be modelled in the transportation modelling system Sampers and outputs will be used as input to create related noise maps in CadnaA using the interface methods created.

Next scenarios will be implemented and analysed. Moreover a geographical key for the study area Södermalm will be created. Possibly evening and nighttime traffic will be modelled and noise levels on local streets analysed in scenarios where it is considered relevant.

0.7 RELATION WITH THE OTHER DELIVERABLES (INPUT/OUTPUT/TIMING)

The Data Terrain Model used when calculating noise maps has been developed in SP1.

The results are in the first place an input to deliverable D2.12 Scenarios for "Traffic control measures for vehicles". The noise mitigation measures developed in this sub work package will also be analyzed in WP 2.3.6 where all measures studied in WP 2.3 will be ranked considering performance/cost, general applicability and general acceptance, resulting in D2.16 Ranking of different noise source mitigation measures. The models developed will also be used in SP5 in relation to the Stockholm test site study.

1 INTRODUCTION

This document describes the methods and traffic models used in work package 2.3.2 to evaluate impacts noise mitigation measures related to traffic control. In collaboration with acousticians at Acoustic Control we are developing a procedure using traffic simulation models and a noise map software as tools.

1.1 BACKGROUND

QCity is a project in EU's sixth framework programme. The aim 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. The project will support European noise policy to eliminate harmful effects of noise exposure and decrease levels of transport noise creation, especially in urban areas. A major objective is to provide municipalities with tools to establish noise maps and action plans (Directive 2002/49/EC) and to provide them with a broad range of validated technical solutions for the specific "hot spot" problems they encounter in their specific city.

1.2 TASK DESCRIPTION

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, some effort will be put in calculation of such effects. This work package will look into the impact of traffic control measures in this respect. Different scenarios will be analysed and compared using traffic forecasting models and acoustic models. The changes in flows and speed that occur for different traffic control strategies will be 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 to be studied.

Although the project has a focus on "hot spots" and "quiet areas", attention will also be paid to the whole urban area as different control measures often have system wide effects. We will use the Sampers transportation modelling system (Transek, Sweden) and its existing model modelling trips in an area including Stockholm County (illustrated in Figure 9 and Figure 10). Traffic control measures will be applied in sub areas of the model network. For these areas we create noise maps using the software CadnaA (Datakustik GmbH, Munich) and study the measures' impact on noise levels. In addition, accessibility, environmental and road safety effects can be analysed at a regional level.

Two study areas in Stockholm municipality have been selected, Järva and Södermalm. The first area represents a suburban region with road types varying from local streets to European highways and different forms of public transport such as buss and commuter train. The second area represents an urban environment in the centre of Stockholm.

Figure 11 shows an orthographic photo of Stockholm municipality and the study areas encircled in white.

Figure 9 Sweden and the location of model area coloured in blue.

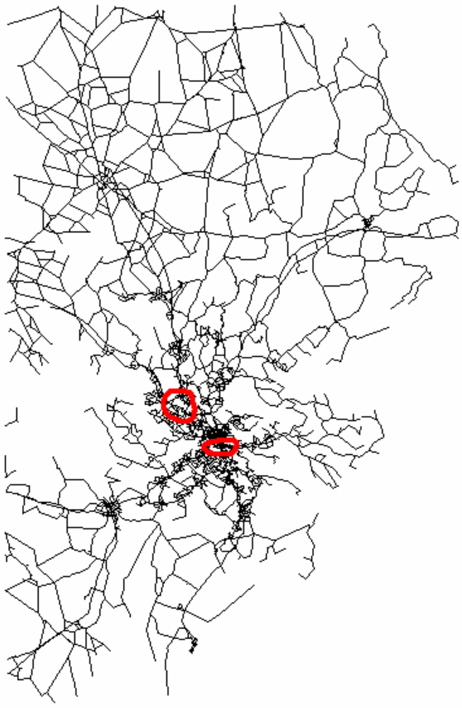

Figure 10 The model network shown with study areas encircled in red.

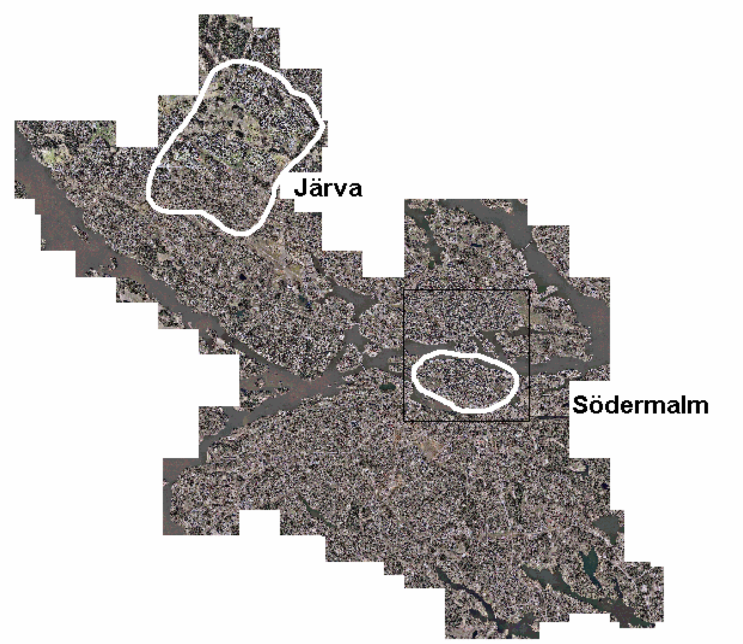

Figure 11 Orthographic photo of Stockholm Municipality. Study areas encircled in white and City centre marked by black square.

2 METHOD

This chapter gives a short introduction to the concept of traffic forecasting and describes the transportation modelling system and noise map software used in our studies. An important issue to handle is the interface between the two modules described in paragraph 2.3.

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 (Report 2.2 Suitability of traffic models for noise modelling). 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.” Each model has its own strengths and weaknesses, and in the QCITY project therefore different types of traffic models are used in different applications. In each case, the practical situation in terms of data and model availability needs to be taken into account.

2.1 TRAFFIC FORECASTING

Traffic is a result of people’s choices. Where to travel, in what kind of mode, on which route and at what time, are all choices we make for a journey. With traffic models we try to simulate these choices using people’s values derived from actual behaviour in traffic. To evaluate effects of a change in the traffic system like a new road or introduction of tolls, traffic models are helpful tools. Consequently traffic forecasts are often used to support decision-makers when evaluating different solutions of current traffic problems or future scenarios.

Traffic models are based on two important components, traffic demand and traffic supply. The individuals that travel through the network in different modes constitute traffic demand whereas traffic supply is defined by the traffic network and the public transport system the travellers can use making their trip.

Depending on the sort of traffic scenario to be studied different traffic simulation models to model supply are used. There are three main types of models, macroscopic, microscopic and mesoscopic. A macro simulation model describes the traffic at a high level of aggregation based on flows. It is a static model that takes a “snapshot” of traffic flows, and the network is simplified to a representation of links and nodes. Micro simulation models are dynamic models where each vehicle is simulated individually. The network is built in detail and traffic controls such as traffic signals and yield signs are modelled. Both macroscopic and microscopic models apply behavioural models to simulate how vehicles interact in the system, though micro simulation models model driver behaviour at a higher level of detail. In short a mesoscopic model is a combination of macroscopic and microscopic models.

2.1.1 The Sampers forecasting system

When studying traffic control measures in QCity we use the transportation modelling system Sampers (Beser and Algers 2002) which contains a multimodal travel demand model system and which is integrated with the analysis package Emme/2 (Inro, Canada). It 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. Figure 19 on page 21 illustrates the structure of the model, and the next two paragraphs give a more detailed description.

2.1.1.1 Basic model structure

The Sampers system is built on a four-dimensional model, reflecting choices people make in the dimensions of trip generation, trip distribution, mode choice and route choice.

The three first dimensions are modelled simultaneously using discrete choice models of the nested logit type (Ben-Akiva, Lerman 1985). This implies that the probability to choose each possible combination of alternatives in the three dimensions (to travel or not, to what destination, by what mode) is calculated for each person in the area. The results are then aggregated to a level describing the total traffic demand between each origin and destination zone pair for each mode. For route choice, a network assignment procedure is used to be able to consider congestion effects of travellers' route choice.

Different variables are used to describe the alternatives in the different dimensions. The nested structure of the model allows factors affecting one dimension to also affect choices in other dimensions (a change in parking costs in one area will not only affect mode choice, but also destination choice and the choice to make a trip at all). Below, some examples of variables used to describe different choice dimensions are given:

Trip generation: Trip generation, i.e. in the choice to make a trip, varies often by socioeconomic category, and variables like age, gender, income and car-ownership are often used.

Trip distribution: This relates to the choice of destination (i.e. destination zone). An individual makes her choice based on the attraction of the destinations as well as the generalised cost (time and money) to reach different destinations. The attraction variables are different depending on the trip purpose. For work trips a part of the attraction can be the number of working sites, while for shopping trips the attraction may be described by the size of stores and the number of stores in an area.

Mode split: Mode split is a consequence of people's mode choice, which is influenced by travel cost and travel time, components like wait time, in vehicle time and access time. Also, socioeconomic variables can have an influence – it is often the case that men are more likely to use the family car than women.

Network assignment: In order to make it possible to consider peoples route choice with respect to congestion, a network assignment procedure is used that achieves consistency between route choice and network congestion. This is modelled in Emme/2 by the concept of network equilibrium (Ortúzar, Willumsen 1990). Each link is associated with a volume-delay function describing how travel time varies with traffic volumes based on the capacity of the link; see the general characteristics in Figure 12. Turning vehicles can also get so called turn penalties in the nodes (road junctions) to account for delays due to signals etc.(. An iterative algorithm is used to obtain the equilibrium situation. The final solution describes flows in accordance with Wardrop's user optimum principle where no traveller can decrease his or her travel time by changing route. For public transport, route choice of public transport submodes is modelled by the so-called Optimum Strategy approach (Spiess and Florian 1990). Here a passenger will pick the transit line or combination of transit lines that minimizes his or her travel time considering travel time in the vehicle, connection times and waiting times. For slow modes walk and bike people are modelled to use the shortest path.

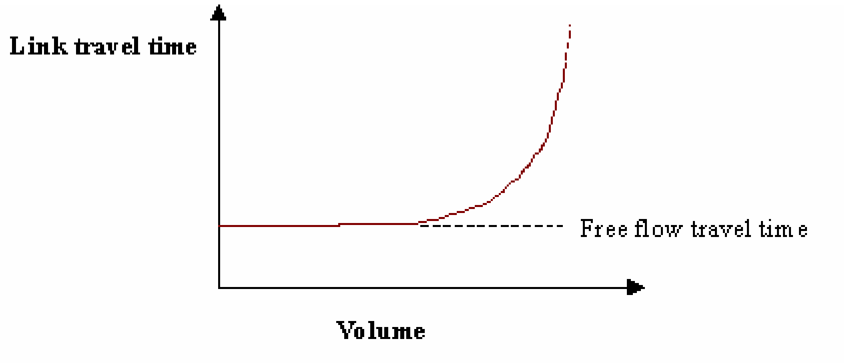

Figure 12 Characteristics of a volume delay function.

Finally, in situations with congested networks, it is necessary to recalculate the travel demand and redo the network assignment in an iterative process. As the generalised cost of a link is based on the number of travellers travelling on the link the costs previous to and post to a network assignment may not be equal. Hence an iterative process between the demand model and the network assignment model results in a solution were there is consistency between choices in all dimensions and the level of congestion, reflected in travel times on the network. These iterations are often very time-consuming and therefore generally only a few iterations are made.

2.1.2.1 Features in Sampers used in Qcity

Samper contains submodels for all trips in Sweden, international, long distance, regional and local trips. As local traffic control policies applied in the study areas may affect a whole region, we model regional and local trips of an area including all of Stockholm County (illustrated in Figure 10 on page 11), using the submodel for regional and local trips. Long distance trips and heavy traffic are also included, but are fixed in terms of Origin and Destination (but can change routes). Using extra modules in Sampers we may for each measure also calculate environmental and road safety effects as well as costs and time gains and time losses. These modules will be used in addition to analysis of noise level impacts in the study areas.

The 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. The complete network consists of approximately 6 000 regular nodes and 1 500 centroids. A centroid is a node symbolising a zone generating or attracting trips. Each centroid has related fictive links called connectors on which traffic demand is distributed to the network. Figure 13 shows the study area Södermalm encircled in red where centroids and connectors are illustrated in green and regular nodes and links in black. Each link has a direction defined by a start-node and an end-node. Accordingly a two-way street is represented by two links with reversed directions. (Note that a link and its reversed link are given equal geographical representation.)

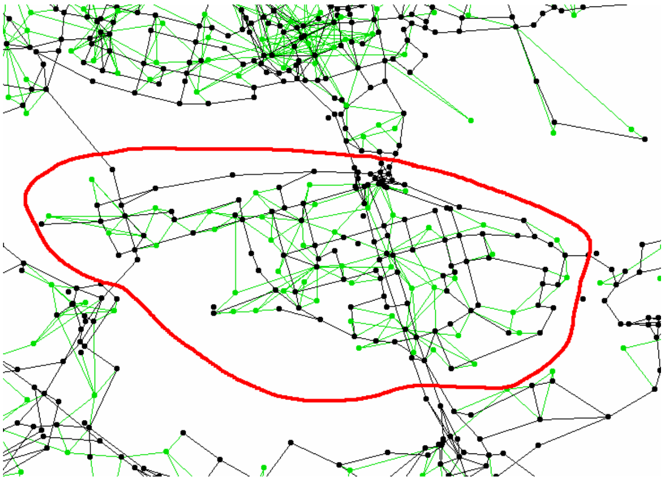

Figure 13 Study area Södermalm modelled in Emme/2.

Attributes describing links and connectors are mode, length, number of lanes and volume delay function. Numerous functions are defined to model different kinds of roads such as free ways and local streets. The mode attribute describes which modes are allowed on a link, e.g. train to model a railroad or buss and car to model roads. Transit lines are defined by the link attributes name, transit mode, vehicle type, headway and speed. Transit mode illustrates if it is e.g. a buss or a train line whereas vehicle type describes if it is e.g. a commuter train or a high-speed train. Headway is the frequency of the transit line, i.e. the average time interval between two departures.

The road network and public transit lines are modelled in the integrated analysis package Emme/2. When evaluating different traffic control policies as restricting car traffic to specific links and restricting speed, the package is used to introduce these changes in the origin model network. For example it is possible to restrict car traffic in an area by not allowing cars on the specific links, or reduce speed limits by changing volume delay functions. Note that all changes affect the whole travel pattern. If a strategy is to forbid car traffic on a link, this will force people who used to travel on the link to choose another route. However they may also change destination, mode or even cancel the trip, all depending on the change in accessibility due to the policy.

If a traffic forecast is made for future conditions, it is possible to set parameters in Sampers related to national factors such as economic development and changes in petrol taxes. However this feature will not be used in this task, as all changes are assumed to take place “today”. We only make modifications related to the network and keep all other variables and parameters fixed. Hence we can study effects of a traffic policy by comparing its results with the traffic pattern of a base scenario represented by the original network.

Sampers models six different trip purposes: work, business, school, social activities, recreation and other. In the network assignment procedure, the resulting demand is divided into several user classes with different values of time. This is necessary to reflect different route choice behaviour for different user classes when economic restrictions are imposed. The value of time parameter reflects the amount of money a traveller is willing to pay to decrease his or her travel time by one time unit. As an example the transport industry such as logistics firms belong to the group with highest value of time. To a large extent, results pertaining to different categories can be displayed. This option is used when input data to the noise map software is calculated, for details see section 2.3.2.

What is not modelled in most traffic simulation models including the Sampers model used is departure time choice; i.e. at what time travellers decide to actually make their trip. This dynamic feature is important since the travel times depend of the number of vehicles travelling in the network. However in Sampers it is handled on a highly aggregate level. A day is divided in three time periods, 7-9 a.m., 9 a.m.-16 p.m. and 16-18 p.m., reflecting the peak and off peak conditions. Traffic demand for each trip purpose and user group is distributed to these time periods in different shares. For example all work and school trips are set to take place in the peak hours (the first and the last period). The periods and distributions have been set to capture the dynamics of traffic during the day. An illustrative example is Figure 14 showing the traffic distribution on a European highway south of Stockholm City, with model periods marked in green.

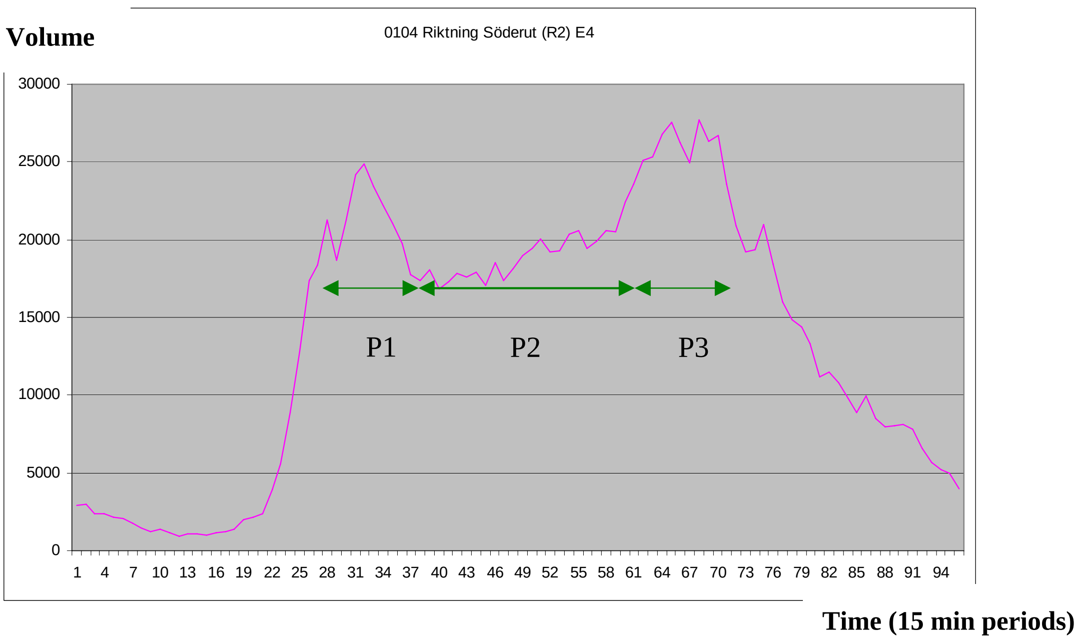

Figure 14 Traffic distribution during a day

Simulation of travel demand for the first and the last period are assumed to give similar results (however with reversed direction). Thus by only simulating the first and second time period, representing peak and off-peak hour traffic, calculation time is saved. Nevertheless the simulation time for our base scenario used in Qcity is approximately 30 hours.

The outputs of a simulation represent traffic conditions of an average hour of each time period. Figure 15 illustrates a part of Stockholm County and the auto volumes for a morning peak hour in our base scenario, study areas encircled in blue. Figure 16 illustrates an off-peak hour volume.

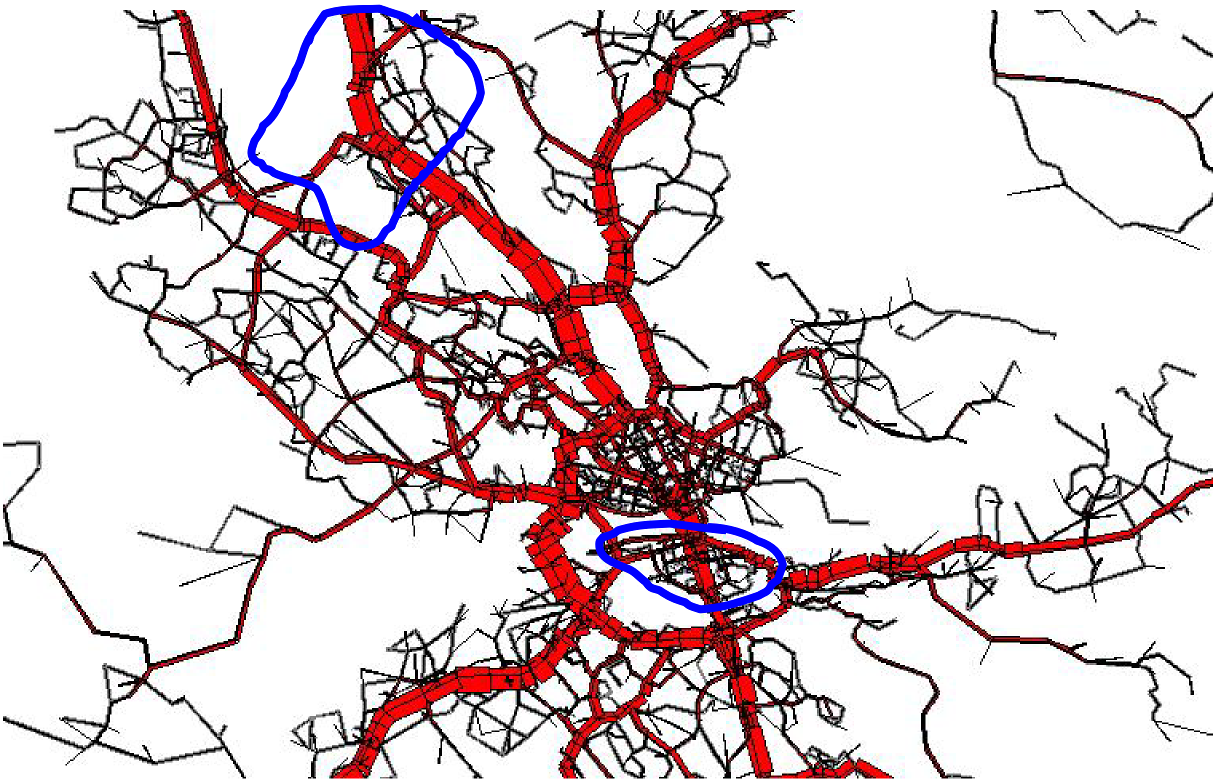

Figure 15 Average automobile traffic volumes of morning peak hour (base scenario).

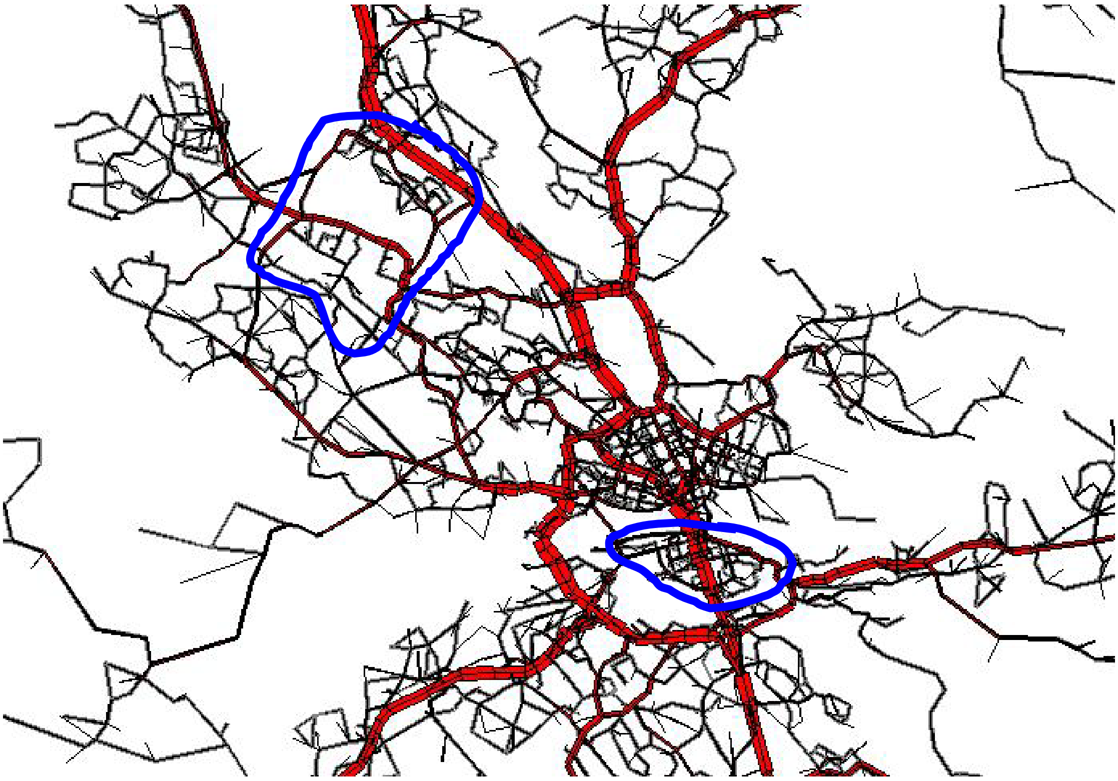

Figure 16 Average automobile traffic volumes of off-peak hour (base scenario).

In a congested traffic condition like the morning peak hour in Stockholm, the model captures the reduction in speed due to capacity constrains. This is exemplified in Figure 17 showing the link speeds of the base scenario in the study area Järva. The formally allowed speed limit of the road “Hjulstavägen” marked in green is 70 km/h. As illustrated, simulation results in lower values particularly on the links with direction towards the city centre where the speed is approximately 40 km/h. However for off-peak hours the speed is approximately 60 km/h on the same stretch of road, illustrated in Figure 18. This feature is important when creating noise maps, as speed is an important noise factor. Another issue is the fact that the official speed limits are generally used as input when calculating traffic noise levels. The uncertainty of speeds (and flows) modelled by the assignment model may also be an issue when using the model to provide input to noise calculations. For this task, 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 here.

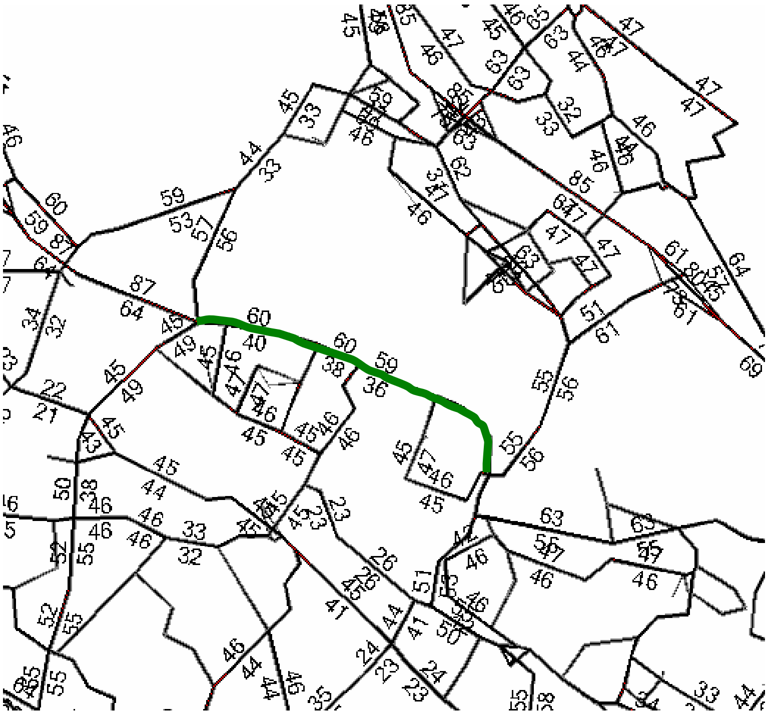

Figure 17 Link speeds in Järva morning peak hour (base scenario).

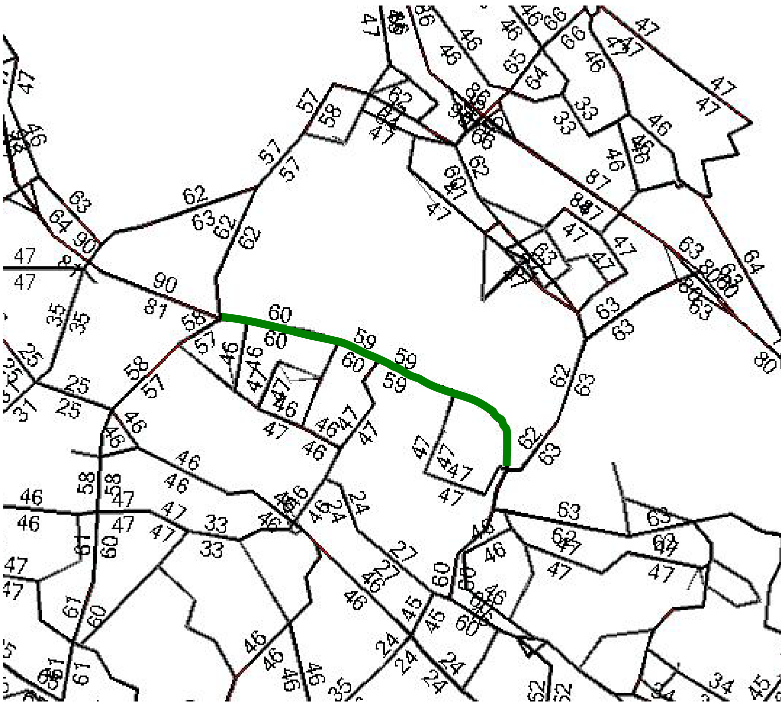

Figure 18 Link speeds in Järva off-peak hour (base scenario).

Finally Figure 19 gives an overall picture of the structure of Sampers and its integration with Emme/2. Note that a traffic control policy applied on the network is input to Emme/2.

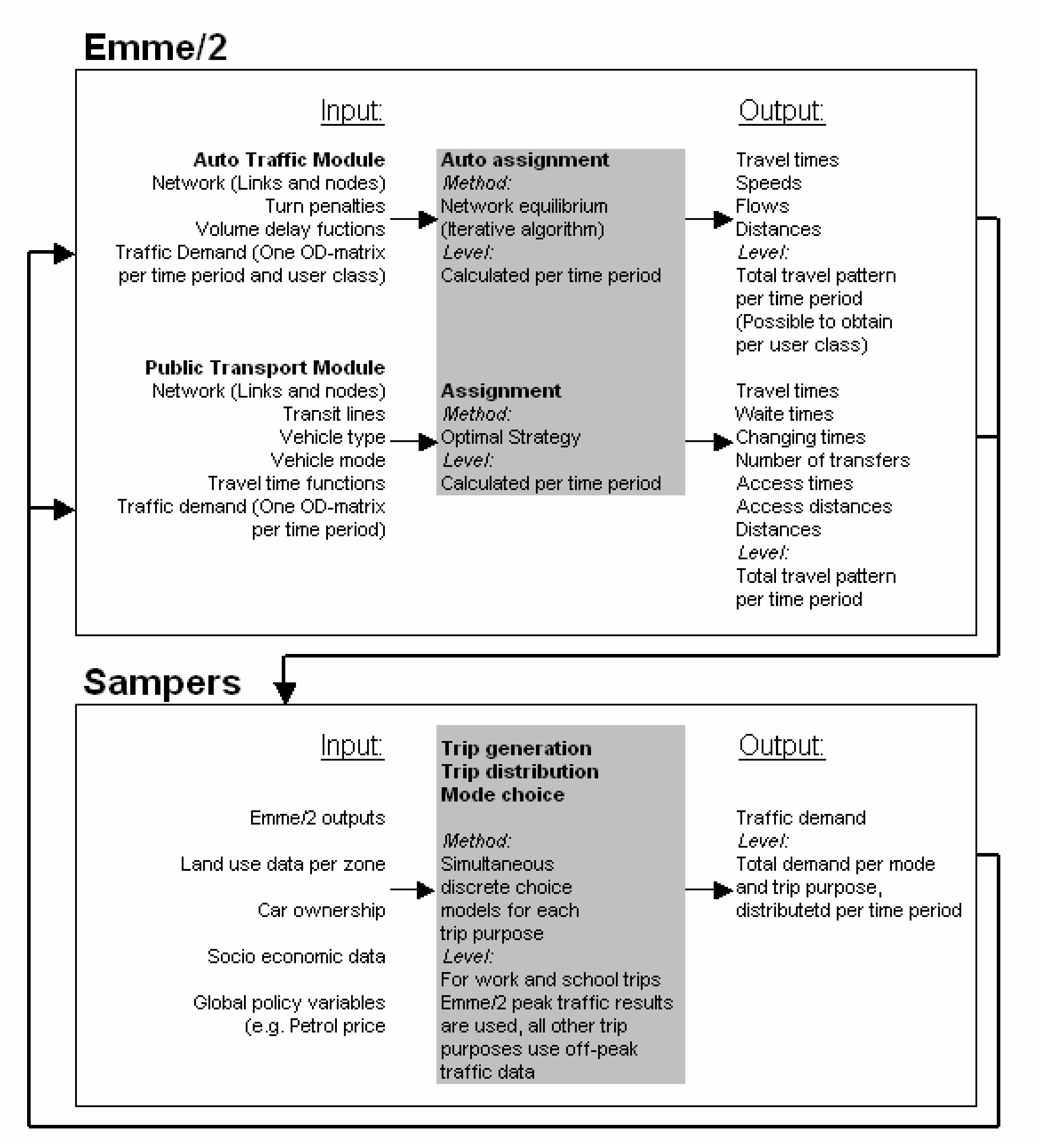

Figure 19 Structure of the transportation modelling system Sampers and its integration with Emme/2.

2.2 THE NOISE MAPPING SOFTWARE CADNAA

When creating noise maps CadnaA (developed by Datakustik GmbH, Munich) will be used. CadnaA is a commercial software, continually updated and improved with the latest prediction methods and calculation algorithms.

Calculations will be performed according to official Nordic prediction methods for respective source. For road traffic noise the Nordic prediction method for road traffic noise, rev. 1996, will be used.

The CadnaA software automatically manages the effects of ground absorption, screening, reflections etc. according to the official prediction method.

Calculations demand a 3 dimensional map (Data Terrain Model, DTM) as well as data for the different kinds of sources, e.g. the amount of traffic on a specific road or the sound spectrum for a specific source.

The terrain model is built with contour lines defining the height along the line. Locations of larger wooded areas, lakes shore lines, locations of buildings and screens as well as their height are then implemented to complete the digital terrain model (DTM). The DTM used in these studies have been developed in SP1 and more information is found in deliverable D1.1.

The 24 hours representing the day is divided according to the EU directive 2002/49/EC;

- Day 06 - 18
- Evening 18 - 22
- Night 22 – 06

Traffic data needed to calculate noise levels is speed, flow and share of heavy vehicles of a road represented per time period. In addition it is possible to calculate noise levels of each period separately.

The roads as well as the railways are fitted to the DTM. The bridges and overpasses are taken into account by letting the road “float” at the defined height. No source are placed when roads or railway are in a tunnel.

When the sources are in place the calculations result in a grid showing the calculated sound pressure level. For the study areas in Stockholm the grid will have a receiver spacing of 10 by 10 meter and a receiver height of 4 meter.

More information about CadnaA can be found on the webpage www.cadna.de.

2.3 ADAPTING TRAFFIC FORECASTS TO NOISE MAPPING SOFTWARE

In order to use the outputs of Sampers as input to the noise mapping software CadnaA we have to create an interface. As the two models work with different graphical representation in different geographical reference systems, the first step is to create a key between the networks; this was made using SweTrans (SWEGIS, Sweden) a software to transform GIS shape files to different graphical reference systems and the GIS software ArcView GIS (ESRI, USA). A match has been developed for the study area of Järva and the key for Södermalm is under construction. Secondly the traffic data outputs of a macro simulation have to be modified to match the inputs needed to create noise maps.

2.3.1 Geographical correspondence

A basic input is shape files describing roads of the study areas. The files are represented in the Stockholm local reference system ST74 and are used as input to CadnaA when noise maps are created. Roads are divided into two segments, main roads and local streets and are represented by polylines in two different shape files (shown in Figure 20, main roads in black, local streets in blue). A European highway is running traverse the study area farthest north (in Figure 20 coloured in green).

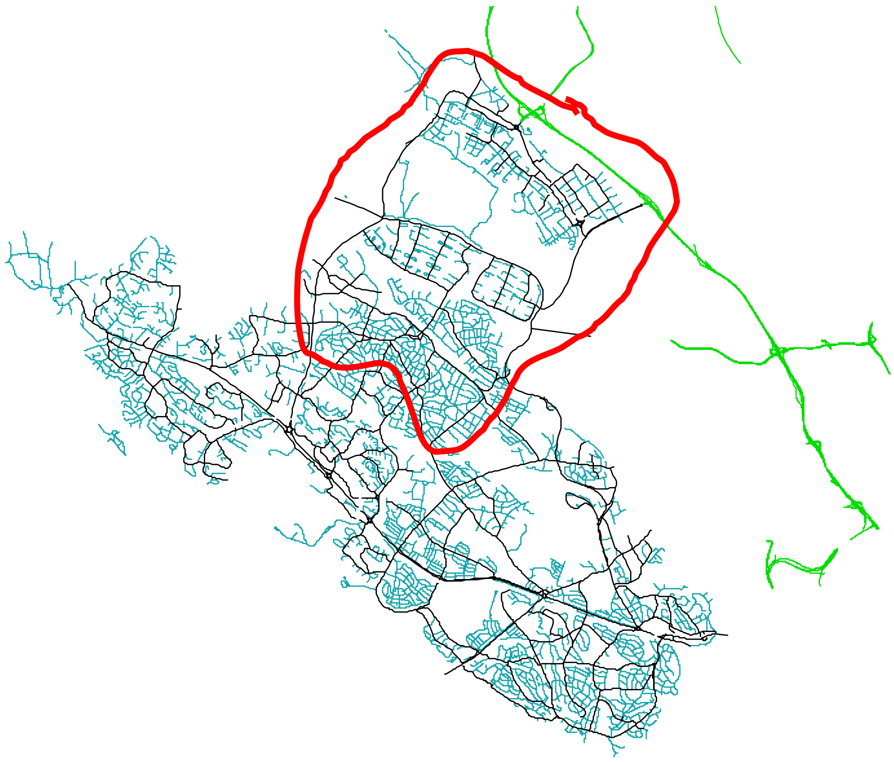

Figure 20 Main roads, local streets and European highway E4. Järva study area encircled.

Via a short script in ArcView we could create shape files of links and nodes of the model network defined in Emme/2. By using SweTrans the files were transformed from the reference system used in Emme/2 (RT90 2,5 gon V 0: -65) to ST74. Figure 21 shows the model road network of Järva and Figure 22 main roads and the model network represented in ST74.

Figure 21 Road network of Järva in Emme/2 (reference system ST74).

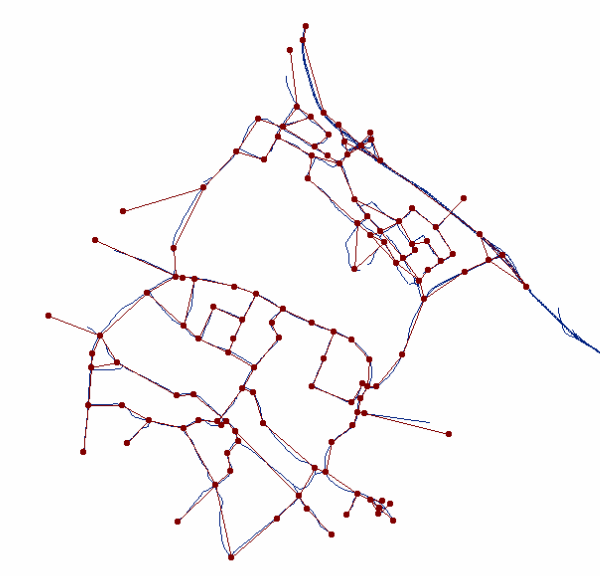

Figure 22 Emme/2 network and main roads (reference system ST74).

Once the two networks were represented in equal format, in equal reference system using ArcView we could manually create a key between the roads in the shape file used in CadnaA and the links in Emme/2. (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). Four different relations were treated: 1:1, 1:n, n:1, and no straightforward match.

In the case of a one to one relation the nodes representing the associated link were added to the attribute data base file of the corresponding road. If a road represented a two-way street the reversed node combination was also added. An example is illustrated in Figure 23 and the corresponding node connection is shown in Table 1.

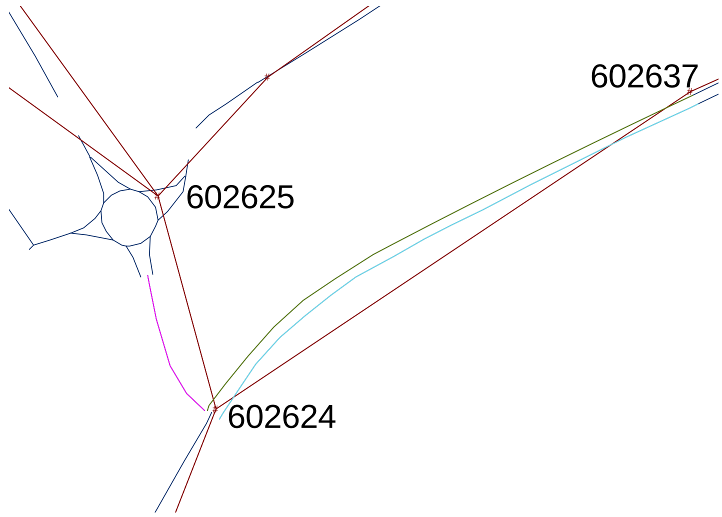

Figure 23 Network example.

Table 1 Example of link/node connection

	Fnode1	Tnode1	Fnode2	Tnode2
Green road	*602637*	*602624*	*0*	*0*
Turquoise road	*602624*	*602637*	*0*	*0*
Cerise road	*602624*	*602625*	*602625*	*602624*

If one road corresponded to several links the road polyline was split into the same number of polylines as there were related links and like the one to one case the link/node relation was added to the dbf-file. (The cuts were made at positions on the road polyline that corresponded to the positions of the nodes in the Emme/2 network.) In some situations more than one road polyline corresponded to one link. Here the identical node relation was added to each road.

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 23, can not be related to any link and they are therefore excluded when noise maps are created. In conclusion we want to emphasize that local areas containing roads with no straightforward match should be treated with extra care when noise maps are analysed.

When creating the key we started working with the shape file describing main roads. Roads that could not be related to the Emme/2 network were consequently moved to the local street shape file. In addition some of the local streets were represented in the

Emme/2 network and were therefore moved to the main roads shape file. As a result the main roads shape file only contains roads with link connections whereas the local streets shape file have no direct link match. (Note that this is the main road shape file illustrated in Figure 22.) Finally for both shape files each road was given a unique identification number.

2.3.2 Traffic data interface

The key between main roads and Emme/2 links makes it possible to transfer traffic data results from Sampers to the road network used in CadnaA. However the inputs needed in CadnaA are not at the same aggregation level as the outputs of Sampers. Therefore a program was written in Matlab (MathWorks, USA) to recalculate selected simulation data.

2.3.1.2 Main roads

As described in paragraph 2.1.1 outputs of Sampers are average values per hour of each time period simulated. Using an Emme/2 macro we create ASCII files with outputs represented per link for every time period simulated, one for automobile results and one for public transport results. The outputs saved are described in Table 2 below. A specific user class contains truck transports and the value is used when calculating the share of heavy vehicles on a road.

Table 2 Outputs stored in ASCII files

Automobile traffic	Public Transport
Traffic volume [Vehicles per hour]	Traffic volume [Vehicles per hour]
Speed [Kilometres per hour]	Speed [Kilometres per hour]
Traffic volume of class 5 [Vehicles per hour]	

The interface program created reads and stores the simulation outputs files as well as a text file describing the key between main roads and links. The text file is a selection of the database file associated to the main roads shape file and contains the road id-numbers plus the link or the link and return link related to each road.

Using the road/link relation and the definitions below we compute traffic volume, speed and share of heavy vehicles of a road per time period 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.

F_i Average traffic flow on road *i* [vehicles per hour]

V_i Average speed on road *i* [kilometres per hour]

$S_{hw,i}$ Share of heavy vehicles on road *i* [percent]

$F_{au,i}$ Auto volume of the link related to road *i* [vehicles per hour]

$F_{aur,i}$ Auto volume of the return link related to road *i* [vehicles per hour]

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

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

$F_{5,i}$ Volume of class 5 (heavy traffic) of the link related to road *i* [vehicles per hour]

$F_{5r,i}$ Volume of class 5 (heavy traffic) of the return link related to road *i* [vehicles per hour]

$V_{au,j}$ Auto speed of the link related to road *i* [kilometres per hour]

$V_{aur,j}$ Auto speed of the return link related to road *i* [kilometres per hour]

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

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

$$F_i = F_{au,i} + F_{aur,i} + F_{pt,i} + F_{ptr,i} \qquad (1)$$

$$V_i = \frac{V_{au,i} \cdot F_{au,i} + V_{aur,i} \cdot F_{aur,i} + V_{pt,i} \cdot F_{pt,i} + V_{ptr,i} \cdot F_{ptr,i}}{F_i} \qquad (2)$$

$$S_{hw\,i} = \frac{F_{5,i} + F_{5r,i} + F_{pt,i} + F_{ptr,i}}{F_i} \cdot 100 \qquad (3)$$

In a first step we calculate traffic data for peak traffic and off-peak traffic respectively, moreover we weigh together the results to obtain values representing an average daytime hour to use as input to CadnaA. As the time periods simulated represents traffic conditions between 07-09 a.m. and 9 a.m.-16 p.m. and in CadnaA a day is defined between 06 a.m. – 18 p.m., we use the weights 4 hour peak traffic and 8 hour off-peak traffic respectively. Using this relation and indexes *p*, *op and D* representing peak hour, off-peak hour and day results, we calculate day traffic data using the formulas 5, 6, and 7.

$$F_{D,i} = \frac{4F_{P,i} + 8F_{OP,i}}{12} \qquad (5)$$

$$V_{D,i} = \frac{4V_{P,i} + 8V_{OP,i}}{12} \qquad (6)$$

$$S_{hw\,D,i} = \frac{4\left(F_{P5,i} + F_{P5r,i} + F_{Ppt,i} + F_{Pptr,i}\right) + 8\left(F_{OP5,i} + F_{OP5r,i} + F_{OPpt,i} + F_{OPptr,i}\right)}{4V_{P,i} + 8V_{OP,i}} \cdot 100 \qquad (7)$$

The results as well as the road id-number are stored in a text file where the same attribute names used in CadnaA is applied. Using the id-number as key we are able to connect the traffic results to the database associated with the main roads shape file and thus obtain a geographic file with input data ready to use in CadnaA.

In CadnaA it is possible to calculate noise levels also based on evening and nighttime traffic conditions. The general use of traffic simulation models is to model traffic during daytime as this is the period of time when traffic systems are most loaded and vulnerable. However, for these studies it is possible to model evening and night conditions by using shares of the travel demand related to the off-peak hour period with distribution in accordance with the dynamics illustrated in Figure 14 on page 17.

2.3.2.2 Local streets

For cases when there is an interest to study the impact of a measure on local streets we have developed an additional method, as local streets are not represented in the Emme/2 network. Often when noise maps are created template values of traffic data are used for local streets. Our concept is to use template values of speed and share of heavy vehicles and define a template flow value for the base scenario. Using this volume value and the change in travel demand that may occur in each zone when a traffic control policy is implemented we can calculate new flow values related to the policy scenario. Here follows a more detailed description.

Each local street can be associated to the centroid representing the geographical zone used in Sampers in which the street is located. Figure 24 shows local streets in blue, zones with black contour lines and centroids with blue dots. The figure also illustrates an example where streets in red are associated with the centroid in red.

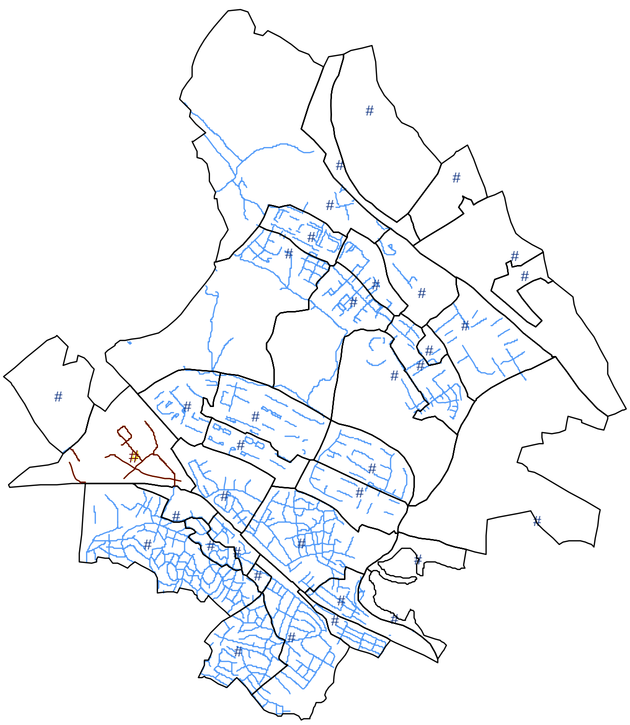

Figure 24 Local streets, zones and centroids of Järva study area.

For each scenario studied the total car traffic volume on connectors related to each centroid can be calculated. A relative change in travel demand is obtained by dividing the connector flows of a centroid in a policy scenario by the connector flows calculated for the base scenario, illustrated in formula 8 using the definitions below.

$Fc_{ps,ij}$ Flow on connector i related to centroid j in policy scenario

$Fc_{bs,ij}$ Flow on connector i related to centroid j in base scenario

R_j Relative change in travel demand for centroid j

$$R_j = \frac{\sum_i Fc_{ps\,ij}}{\sum_i Fc_{bs\,ij}} \quad \forall\, j \qquad (8)$$

To obtain new traffic flow data of a local street k for a policy scenario, template values used for the base scenario are multiplied with the relative change in travel demand for the centroid j associated to the street, illustrated in formula 9.

$$F_{ps,k} = F_{bs,k} \cdot R_j \qquad (9)$$

Thus the concept is clear though the flow template value to use has not been determined. However the method will only give difference in flow and impact on noise levels if a policy reduces car trips in a zone significantly. Therefore one may consider for which policies the method should be applied.

2.3.3 Noise map of base scenario

Using the methods described we have created a noise map of the base scenario in Järva, shown in Figure 25. The map 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.

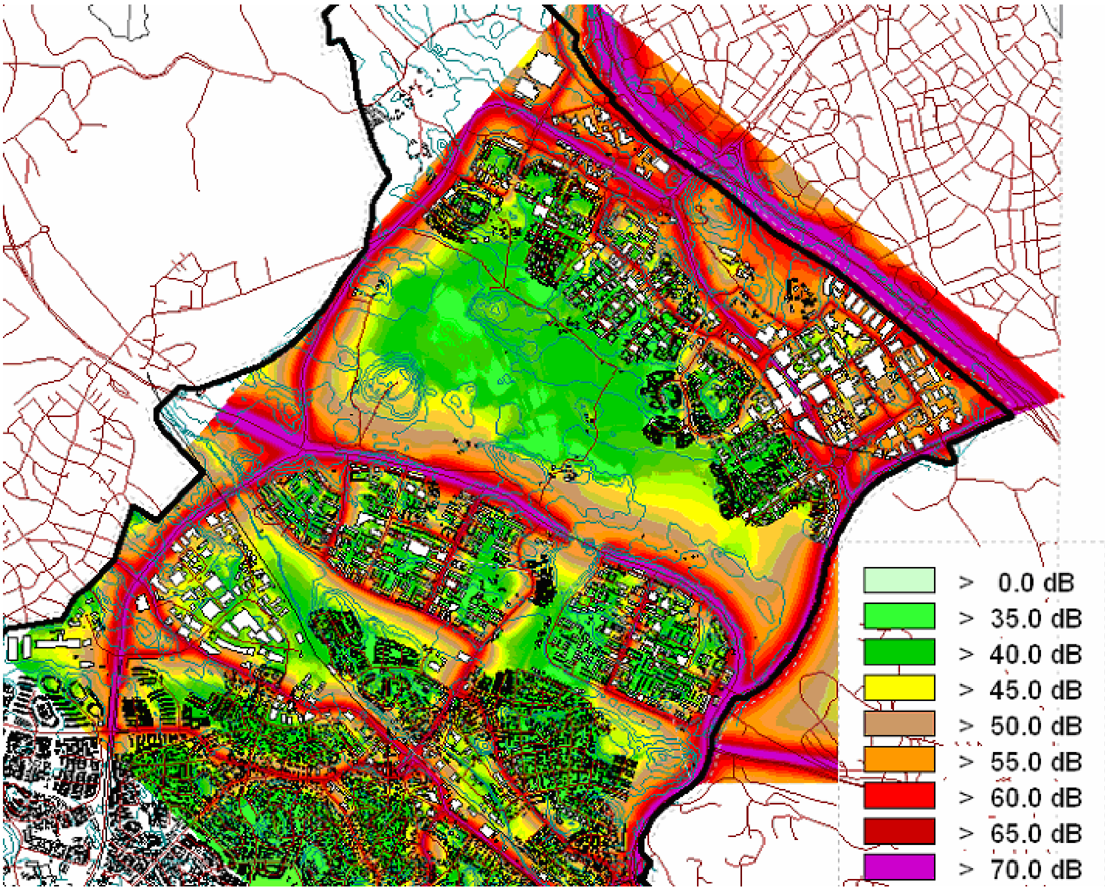

Figure 25 Noise map of base scenario in Järva, Stockholm (L_{Day}).

3 DESCRIPTION OF TRAFFIC CONTROL SCENARIOS TO BE ANALYSED

The different scenarios to be analysed related to traffic control is:

- Restrictions on links
- Restrictions on speed
- Economic restrictions be area or link

Here follow more details on how they can be designed and implemented.

3.1 RESTRICTIONS ON LINKS

In our study areas we will select links on which we want to restrict car traffic. This can be modelled by changing the attribute describing the allowed modes of a link. An illustrative scenario example is shown in Figure 26 where we have prohibited auto traffic on the link located where the arrow points (that is prohibition of through traffic on “Hjulstavägen” marked in green in Figure 17). The picture illustrates the change in auto volume that occurs relatively the base scenario (green marks a decrease and red marks an increase). As expected, the policy makes people reroute their trips. The effect on auto speed is illustrated in Figure 27. Due to the restriction the links of “Hjulstavägen” are no longer congested which makes traffic run smoother for local trips still allowed and as a consequence the link speeds are increased. (Note that for other links with an increase in traffic volume there is a decrease in speed.) The next step is to create a related noise map and analyse the system wide effects of the policy.

Figure 26 Change in auto volume relatively the base scenario due to prohibition against car traffic on link (peak hour).

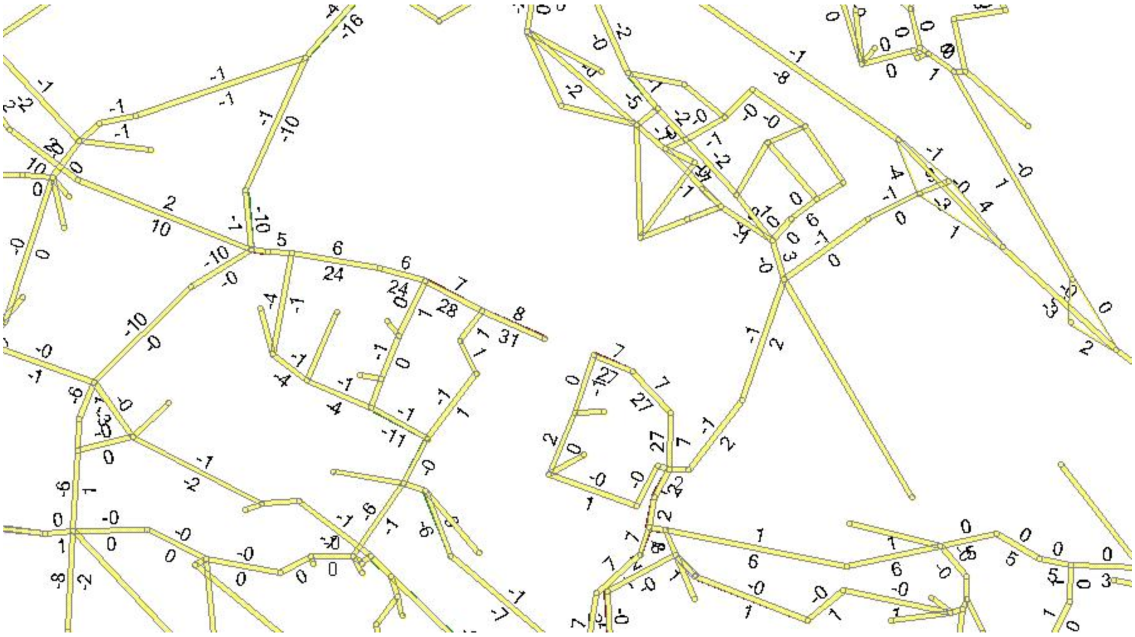

Figure 27 Change in auto speed relatively the base scenario due to prohibition against car traffic on link (peak hour).

3.2 RESTRICTIONS ON SPEED

In our study areas we will select links on which we want to reduce the speed limit by changing their related volume delay functions. As an example we have restricted the speed on the road “Hjulstavägen” from 70 km/h to 50 km/h. Some simulation results are shown in Figure 28 and Figure 29. Figure 28 illustrates changes in auto volume relatively the base scenario in peak hour traffic represented in the same scale as in Figure 26. Thus the policy makes people use new routes, but not to the same extent as in the previous example, which is expected. As illustrated in Figure 29 the auto speed decreases relatively the base scenario though less on links towards the city centre than on the links with reversed direction, which is due to different levels of congestion. (The base scenario auto speed is illustrated on 20 in Figure 17).

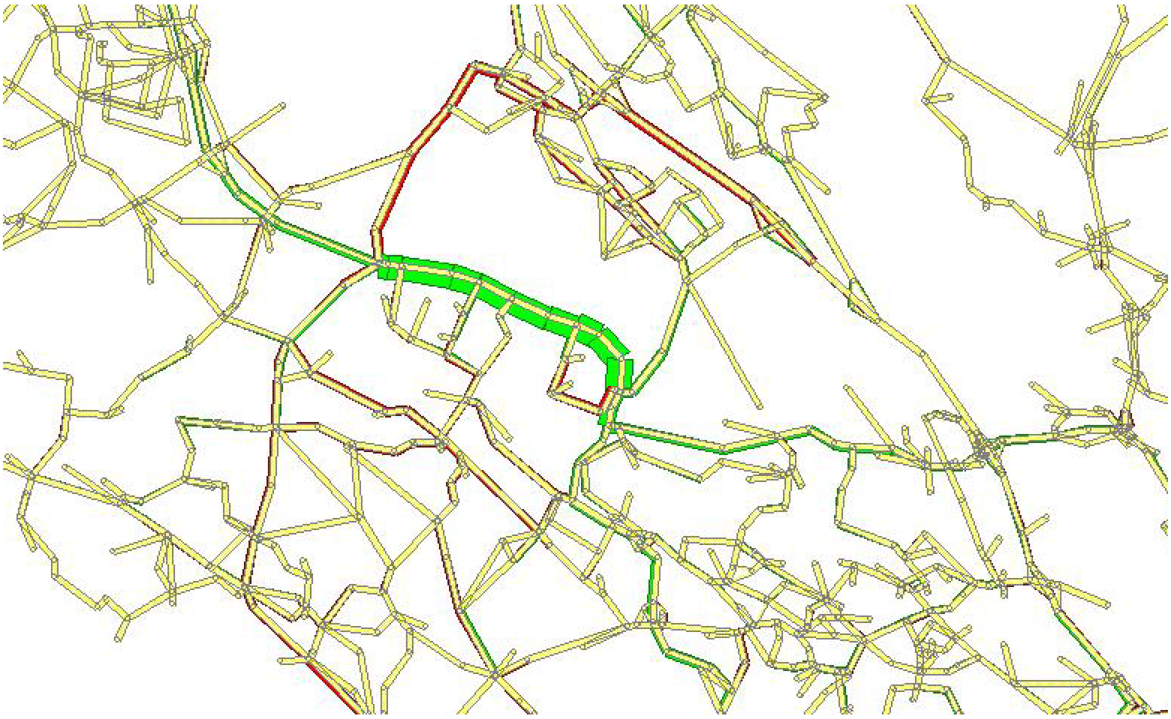

Figure 28 Change in auto volume relatively base scenario due speed restriction on Hjulstavägen (peak hour). Green decrease, red increase.

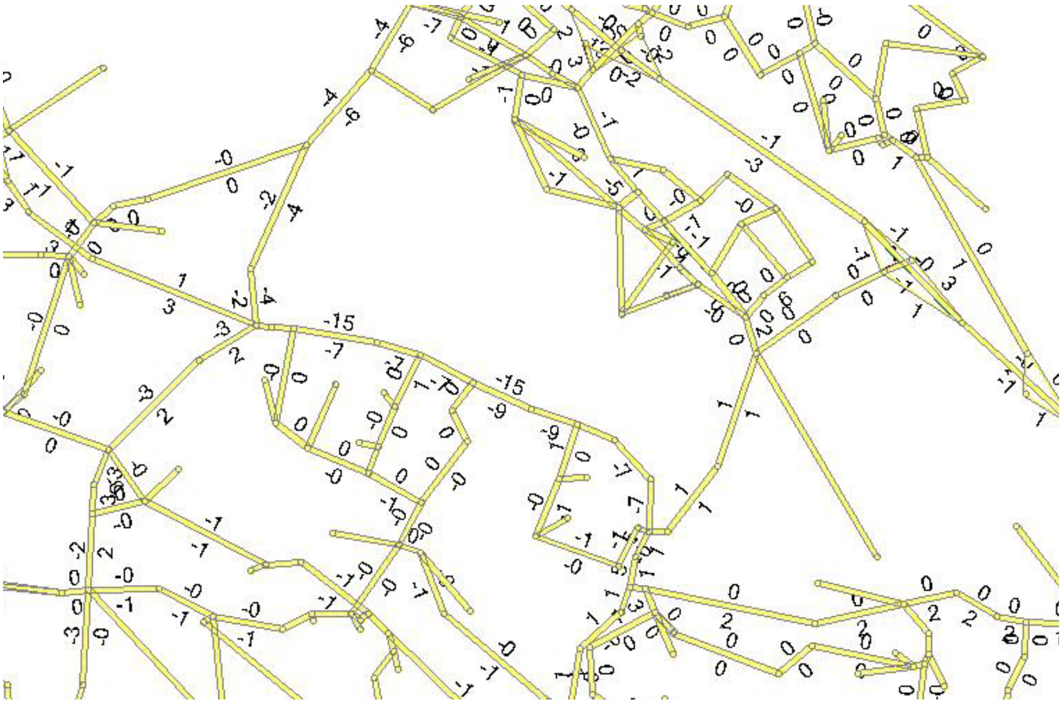

Figure 29 Change in auto speed relatively the base scenario due to speed restrictions on Hjulstavägen (peak hour).

3.3 ECONOMIC RESTRICTIONS

When studying economic restrictions we intend to analyse restrictions for heavy vehicles and introduce the concept of silent cars. Scenarios will be run where heavy traffic is prohibited on specific links and on links where we previously forbid car traffic, silent cars will be allowed. Other scenarios that may be modelled is to introduce tolls where silent cars do not need to pay the charge and introduce zones where noisy cars must pay high fees to enter.

Silent cars can be modelled by identifying the share of silent cars owners and putting them in a new user group in the assignment procedure. We may then say for example that 10% percent of the total car stock is silent cars and 90% normal noisy cars. Simulation results for different user groups can be obtained which makes it possible to calculate traffic data related to the different vehicle types to use as input to CadnaA.

4 CONCLUSIONS

The basic concepts to use in work package 2.3.2 are clear. Different traffic control scenarios will be modelled in the transportation modelling system Sampers and outputs will be used as input to create related noise maps in CadnaA using the interface methods created. During the model and interface development we have not encountered any major problems that have made us reconsider this overall approach.

Next, effects of the scenarios simulated related to speed and link restrictions will be further analysed and other scenarios implemented. Moreover a geographical key for the study area Södermalm will be created, and new user groups modelled to introduce the concept of silent cars. Possibly evening and nighttime traffic will be modelled and noise levels on local streets analysed in scenarios where it is considered relevant.

5 RELATION WITH THE OTHER DELIVERABLES (INPUT/OUTPUT/TIMING)

The Data Terrain Model used when calculating noise maps has been developed in SP1.

The results are in the first place an input to deliverable D2.12 Scenarios for "Traffic control measures for vehicles”. The noise mitigation measures developed in this sub work package will also be analyzed in WP 2.3.6 where all measures studied in WP 2.3 will be ranked considering performance/cost, general applicability and general acceptance, resulting in D2.16 “Ranking of different noise source mitigation measures”. The models developed will also be used in SP5 in relation to the Stockholm test site study.

6 REFERENCES

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