SCIENTIFIC SUPPORT PLAN FOR A SUSTAINABLE DEVELOPMENT POLICY

Intermediary report - January 2003

AN INTEGRATED INSTRUMENT TO EVALUATE EFFECTS OF LOCAL MOBILITY PLANS ON TRAFFIC LIVEABILITY AND THE ENVIRONMENT
CP-37

VITO – KUL - RUG - LV

SPSD II

PART 1

SUSTAINABLE PRODUCTION AND CONSUMPTION PATTERNS

- GENERAL ISSUES
- AGRO-FOOD
- ENERGY
- TRANSPORT

This research project is realised within the framework of the Scientific support plan for a sustainable development policy (SPSD II)

Part I "Sustainable production and consumption patterns"

The appendixes to this report are available at :
http://www.belspo.be (FEDRA)

Published in 2003 by the
Belgian Public Planning Service Science Policy
Rue de la Science 8 - Wetenschapsstraat
B-1000 Brussels
Belgium
Tel : 32/2/238.34.11 – Fax 32/2/230.59.12
http://www.belspo.be (FEDRA)

Contact person :
Mrs Aurore Delis (deli@belspo.be)
Tel : 02/238.37.61

Scientific support plan for a sustainable development policy (SPSD II)
Part I "Sustainable consumption and production patterns"

First intermediary scientific report

1. Project title

"An integrated instrument to evaluate effects of local mobility plans on traffic liveability and the environment"

2. Introduction

2.1 Context and summary

Sustainable mobility at the local level, in cities, towns or districts, requires a balance between accessibility, liveability and environmental quality. Despite technological progress and strict standards for new vehicles, a balanced local traffic plan is still needed to improve the quality of life and environment in our cities and communities. Local administrations are therefore in need of an integrated instrument to check the impacts of their plans with criteria for district accessibility, liveability (including road safety, pedestrian cross-over possibilities, etc...) and environmental quality (noise and air). We plan to create a methodology that takes the spatial characteristics, traffic situations and social functions of districts and streets into account.

2.2 Objectives

- Develop an integrated methodology for the evaluation of impacts of local traffic plans on accessibility, traffic liveability, noise nuisance and air quality.
- Develop and use new methods and models to evaluate all these impact categories at the district or street level and in more detail than before.
- New recommendations for local policies related to mobility, environment, road safety and urban planning.

2.3 Expected outcomes

The **major results** of this project are:

- An integrated instrument for the evaluation of impacts of local traffic plans on accessibility, traffic liveability, noise nuisance and air quality.
- The demonstration of this model for a case study in a large town or city.
- New methods and models to evaluate all these impact categories at the district or street level and in more detail than before.
- A series of reports and articles that document and discuss these new models and their results (See Annex 6.2. for publication during 2002).
- New recommendations for local policies related to mobility, environment, road safety and urban planning.

Other important results of the project are related to different subtasks:

- A set of emission factors and vehicle fleets data –more representative for local and slow traffic flows and accounting for the traffic-flow dynamic, scope 2000-2010.

- A set of emission factors for alternative forms of (public) transport that can be used in local traffic plans.
- A dispersion model that - starting with emission factors and traffic flows - can generate hourly air quality parameters at the city and street levels (in a GIS-environment), and provide details in the street.
- A dispersion model that - starting from emission factors and traffic flows - can generate noise levels at street level (in a GIS-environment).
- An impact module that converts the results of dispersion models to health impacts. Population distribution is linked to noise and air quality levels to estimate the exposure of different sections of the population. This will be done in a detailed way taking into account time (of day) and location.
- A methodology for the quantification of accident risks, pedestrian cross over possibilities and spatial quality of major road types.
- The development of a monitoring instrument for the estimation of traffic liveability at the local level.
- The creation of a database of liveability indicators linked to liveability levels depending on the typology and function of the district.
- Recommendations for policy makers that take our new insights (concerning pressures of mobility on cities liveability) into consideration. These may include recommendations for the standardisation and control (in-use compliance) of vehicles, technical traffic measures (e.g. speed bumps), and compensatory measures (e.g. spraying of streets, low noise pavements, ...). Most important will be the lessons learnt from the integrated evaluation of specific measures. Notably those measures that get a good score for all the themes.

3. Detailed description of the scientific methodology

3.1 Choice of the case-study

To further develop and demonstrate the integrated instrument, we need a case study that meets certain preconditions. In the case study we will gather an amount of data like the position and height of buildings, traffic counts, meteorological data, size of the population, accident rates… A few measurements and counts will also be executed. On the basis of the data from the case study the traffic flow model can be calibrated and liveability indicators can be calculated including concentrations of pollutants, the exposition of the population to air pollution, noise levels, time needed to cross the street.…

3.1.1 Preconditions

Below we give an overview of the preconditions the case study has to meet. These preconditions relate to the situation in the field (traffic, vehicles, buildings, functions) as well as to data that are available about the case study.

3.1.1.1 Situation in the field

- The vehicle fleet must be various:
  - private cars
  - buses
  - delivery vans
  - trucks
  - motorized two-wheelers
  - tram, trolley, train

These vehicles all have a different impact on liveability. The presence of different vehicle types is also useful to study modal shifts.

- Different speed limits (30, 50, 70) and differences in traffic circulation:smooth traffic, heavy traffic,'stop and go'

- Different functions in the area:
  - important arterial roads
  - companies, administrative centres
  - shops and shopping malls
  - schools
  - train station
  - residential areas
  - recreation

- Different types of housing:
  - open-space development
  - terrace houses
  - high-rise buildings

  The height of the buildings has an impact on the propagation of noise and emissions.

- There has to be a big and heterogeneous population group in the case study. The population group has to be big enough to calculate dose-response curves in a statistically significant way. The population group must be sufficiently heterogeneous so that all age groups and social classes are present.

- The area has to be big enough so that a substantial part of the inhabitants hardly travels outside the borders of the area during an average day. That's why the area has to be provided with different functions.

- There must be enough possibilities in the case study to simulate realistic improvements in the traffic situation:
  - measures that result in a change in traffic circulation (prohibition for trucks, prevent people taking short cuts…)
  - measures that result in a change of the traffic situation (speed bump, one-way traffic, roundabout, road building and maintenance…)

3.1.1.2 Availability of data

Data needed	**Source**
meteorological data	VITO, VMM, KMI
composition of the floor surface	own fieldwork
position and height of buildings	NGI file
background concentrations	measuring station VMM
composition of the vehicle fleet	local authority
detailed traffic counts	local authority
demographic data	local authority
traffic speed data	local authority

Presupposed traffic measures	mobility plan, liveability plan
Data from a macroscopic traffic simulation model	local authority
accident rates	local authority
Orientation, length and width of the street	local authority, GIS file

3.2 Typology

In view of assessing the liveability and environmental quality of a municipality, a city, a city quarter or a specific location, we need to make a distinction between different types of areas with their own traffic characteristics, spatial and environment characteristics and liveability levels. Depending on the type of situation, other liveability levels will be defined and certain indicators will carry more weight than others. The goal is to end up with an environment capacity matrix that, depending on the type of situation, will describe indicators that define the liveability and the environmental quality of the area.

To compose a classification of types of roads / areas we have used different points of view. A first one was to analyse the classification of roads used by the Flemish government. This way of classification emphasizes the function of a road: connect or collect at different scales. Another way was to look to some specialized publications such as the Flemish handbook provisions for traffic in the build-up area "Vademecum Verkeersvoorzieningen in bebouwde omgeving", Vlaamse Gemeenschap (1997) and a publication of a Dutch organization for energy and environment: Novem: "Verkeersveilige stedenbouw – Handreikingen voor een duurzaam veilige wegomgeving" (2002). Langzaam Verkeer has expertise in mobility and spatial planning. For instance, we have classified 100 photos of roads. We acknowledge that this classification is just a first set-up and has to proof itself based on trial and error.

3.3 Modelling of traffic flows

In this study, we use the micro-simulation model Paramics for the modelling of traffic flows. Let's take a look at the input for this model:

- First, we put in the infrastructure, this means the configuration of the road-network, as well as the priority rules, the speed limits, etc…

- Secondly, we bring in the demand of traffic. The demand of traffic defines for each possible route between a certain point of origin and a certain point of destination, the amount of vehicles that try to reach their destination via this particular route. For each interval of time, for example for each 15 minutes, a new demand of traffic is imported in the model. Consequently, the demand of traffic is time-dependent and a dynamic model is born.

- Thirdly, we bring in the properties of the vehicles and those of their drivers. The type of the vehicle, as well as the reaction time of the drivers, influences significantly the behaviour of the vehicles. This is taken into account by the micro-simulation model.

On the basis of this input, the model assesses the movements of each vehicle. Microscopic models, such as Paramics, consider each vehicle separately.

The period of simulation is divided into small intervals, for example intervals with a length of 1 second. At every time step, the model assesses the new position, velocity and acceleration of each vehicle, as a function of the previous position, velocity and acceleration and also as a function of the traffic situation on that particular moment.

In the micro-simulation model Paramics, vehicles take into account a series of side conditions:

- Interaction with other vehicles
- Arrangements of traffic-lights
- Priority rules
- Speed limits
- Lanes for busses
- Etc…

After the assessments, the model shows the simulated traffic flows.
In order to simulate realistic flows, we have to calibrate the model.
With great accuracy, we attach values to a series of simulation parameters to make sure that the traffic flows correspond to reality.

3.4 Air quality

3.4.1 Emissions

3.4.1.1 Dynamic tail-pipe emissions

Based on the output of the traffic flow model Paramics the tail-pipe emissions of the vehicles are calculated. This output details i.a. for every simulated vehicle its position within the modelled network, its instantaneous speed and acceleration.
Two datasets are used for the calculation of the emissions.
At the one hand, emission functions of MEET/Copert relates for a specific type of vehicle its speed to the emitted quantities of various pollutants. As Paramics provides the speed for every vehicle, the tail-pipe emissions of that vehicle can be calculated.
At the other hand, the emission factors of the ‘Handbuch der Emissionsfaktoren des Strassenverkehrs’ are used, which gives for a specific type of vehicle emission factors for a list of well defined traffic situations. These situations are characterised by a average speed and average acceleration. The output of Paramics allows the corresponding emission factors to be selected for every vehicle modelled.

3.4.1.2 Vehicle types

The appropriate emission factors are selected not only based on vehicle speed and acceleration, but also taking into account the type of the vehicle.
The emission factors specified by both the emission functions of Copert/MEET and the ‘Handbuch’ are vehicle type specific, i.e. different emission functions or factors are given for person cars, light duty vehicles, heavy duty vehicles and powered two-wheelers. A finer breakdown is based on fuel technology and/or vehicle weight (both are considered for cars only). Finally, within every segment defined, different emission functions or factors are given for the diverse generations, i.e. the Euro-classes, of the vehicles.
In the list of vehicle types considered room is foreseen for alternative technologies, such as CNG powered buses and hybrid cars.

3.4.2 Atmospheric modelling

For the assessment of the air quality in the study area (Gent-Brugge, Ledeberg), an integrated modelling system, “AURORA” (Air quality modelling in Urban Regions using an Optimal Resolution Approach) will be used. This urban air quality modelling system is most suitable, for urban and regional policy support and reflects the state of the art in air quality modelling. For more detailed local modelling of air pollution at street level the so called “Street canyon” models will be used. This requires 3 types of meteorological data:

1. hourly average windspeeds and direction at roof height
2. temperature
3. incoming radiation (for O3 and NOx modelling)

3.4.1.1 Regional modelling with Aurora

The model input consists of terrain data (orography, land use, road networks) that have been integrated in a Geographical Information System (GIS). Meteorological input data have to be provided with a resolution up to a few hundered meters by a separate meteorological model. The geographical data are obtained by the new road and 3D maps of the National Geographical Institute. These data are integrated in the GIS system. The emission input data have to be the result of a detailed inventory and acquisition of existing emission data, as well as the results of the measured detailed data from this project.
Meteo data of the area are required before starting these simulations.

3.4.2.2 Local model: Streetbox

For more detailed modelling at street level: two models will be used, the “ Streetbox model ” and the OSPM (Operational Street Pollution Model). In the “Streetbox model”, the street is considered as a box with the dimensions of the street. The necessary dimensions are the direction, the length and width of the street and the height of the houses on both street sides. In this model the assumption has been made that the pollutant mixes instantaneous with the air. One uniform pollutant concentration will be calculated for the street or the street segment where the emission data have been measured. A background concentration of the street has to be given as input.
Within the study are a number of typical streets are selected. All data have been digitized and imported in the GIS system (Arcview). Meteo data at 50 and 30 meters have been obtained. Calculations of appropriate wind speed and direction at 10 m above the roof level of the houses will have to be performed. Emission data measured at the selected spots in the area are input for the modelling. For more detailed and complex street parts the OSPM model will be used.

3.4.3 Health impact Assessement

3.4.3.1 New information from recent epidemiological research

Epidemiological evidence for the adverse effects of urban air pollution, with emphasis on particulate matter is abundant. Since the beginning of the nineties it has been demonstrated that long-term exposure to fine particles (PM2.5) causes lung-cancer, cardio- respiratory disease, and early death. Short-term effects on health from PM10 or PM2.5 are consistently measured in a number of studies world-wide. The overall impact on public health is substantial compared to other environmental factors. Several mechanisms and components of PM have been explored to explain these health effects. One of the potential culprits is traffic exhaust, with the emphasis on diesel particles. These ultrafine particles are taken up quite rapidly in macrophages and into the blood, hence the respiratory and systemic inflammatory responses. Adsorbed metals and organic components can also potentially cause DNA damage. A series of Dutch epidemiological studies confirms the traffic hypothesis: proximity to highways increases the risk to severe health effects. The number of diesel trucks is significantly correlated to respiratory effects in children. It is clear that living, going to school or working in urban environment increases exposure. Adequate knowledge of exposure of specific groups in the population is currently insufficient (especially in Belgium: densely populated living next to main roads, with a lot of diesels). We will keep track all available scientific knowledge with respect to exposure to PM in cities, including some new options, e.g. the emissions of particle by petrol cars.

3.4.3.2 Methodology for indoor exposure

Assessing the indoor contribution to the overall personal exposure is crucial, since we spent 80% of our time indoors. Mathematical (approximating) methods to derive indoor exposure are available however. Where possible the results will be tested by measuring.

3.5 Noise

3.5.1 Dynamic Sound

In an urban environment the traffic flow cannot be modelled as a steady state flow of vehicles. Traffic lights, pedestrian crossings, roundabouts,… constantly cause interruptions of the traffic flow. All these factors cause the sound emission to fluctuate strongly and be on the average higher than at free flow with the same mean velocity. Taking the emission dynamics into account is highly relevant.

The traffic model used in this project is a micro simulation that tracks all individual vehicles. A sound emission module is coupled to the vehicle flow simulation. Through a literature study of some of the most common national standards on noise, an appropriate model was chosen. The selected model is the Nord2000 standard on noise. The main advantages are the recent validation of the propagation model and the large dataset of measurements of emissions available.

There are at the moment noise emission data available for 3 vehicle categories: cars, light trucks, heavy lorries. Diversification on basis of engine type is introduced as a correction on the sound emission levels. European standards for noise emission in acceleration also distinguish between cars and trucks (>3.5t), and subdivide trucks according to engine power (<75 kW, >150kW). There is a statistical relation between engine power and maximum load. A recent rolling noise standard categorizes on the basis of tire width. This does not seem important for city driving conditions however.

A considerable effort is needed to extend these emission data to include knowledge on the dependence of sound emission on acceleration obtained from literature and unfortunately in an incompatible form and to map the vehicle classes to the common vehicle classes used in this project.

Dynamic emission has to be described in a way that it can be easily used in the impact assessment. Several indicators for describing the urban soundscape and its dynamics are available (Lden, L10, …). Since we felt that these indicators do not capture the whole picture, spectral content of loudness and pitch variations will be added. These indicators directly depend on the impact model used later on. Additional indicators can be computed to build easy interpretable immission maps.

3.5.2 Generalised Emission Model

Calculating the dynamic emission of large areas of cities can be computationally very expensive or impossible due to lack of data. Some properties of the emission would require a full micro traffic simulation and detailed input data. Therefore a model that is not much more complex than existing emission models needs to be built to predict the dynamic sound behaviour in a street. It should allow bypassing the micro-simulation of traffic flows.

The methodology for building this model was decided upon after careful consideration of alternatives. This model will be based on simulating traffic flows for characteristic situations and storing the emission results of these simulations as exemplars. The model then needs to compare the given environmental settings of the street with the settings of the given characteristic situations. Fuzzy Rule Base systems and Fuzzy Neural Networks will be used for this purpose because they are suitable for modelling very general complex interactions while retaining an easy interpretable set of rules.

The generalised emission model will need input data that is not always available. Default and most likely values will need to be derived from statistics. These input parameters, like the speed distribution of the traffic, will also depend on other, available, geographical properties.

3.5.3 Propagation Model

A literature study has been made of the currant national and international standards. The propagation model needed to be solid, well documented and suitable for urban areas. Not only large areas will be investigated but also smaller neighbourhoods so the model must also be able to take care of high-resolution simulation. To allow for scenario’s to be modelled, a full decoupling of emission and propagation is advantageous. In that manner the propagation can be kept constant while the emission changes from scenario to scenario.

Several calculation schemes are available like boundary elements, volume elements, radiant exchange, ray tracing, beam tracing and more. Considering the scale of the region to be simulated and the frequencies of interest, mainly road noise, only a few methods are applicable. These methods can be categorised as ray-based methods. This bias towards ray-based methods is also noticeable in the national and international standards. Furthermore in urban area multiple reflection and diffraction become important which is explicitly modelled and described.

Several implementation flavours of the ray-tracing techniques are known. The technique chosen takes advantage of the densely occluded environment to accelerate the path tracing. Diffraction is an integral part of the tracing method.

A complication is that geo-referenced information is likely to come from several sources and little distortions of the data can cause artefacts in the combined layers. Care must be taken into pre-processing of geo-referenced data and must be automatically tuned to conform to the input standards to allow easy integration.

4. Detailed description of the intermediary results, preliminary conclusions and recommendations

4.1 Demarcation of the selected case-study area in Ghent

Considering the preconditions mentioned in 3.1.1, it was decided to take the city of Ghent as the case study, more specific the area Gentbrugge/Ledeberg because of the following reasons:

- Few traffic works have been executed, but there are some projects at stake. In this way we can compare the liveability situation before and after the works.
- A mobility impact report (MOBER), a liveability plan and a bicycle plan are available.
- Some drastic traffic works are planned: speed bumps, 30 km/h areas, change in circulation, reconversion of the ARBED-site.
- The possibility to perform some measurements and counts still exists before the traffic works start.
- The case study includes urban area, schools, tram-, bus-, and trolley routes, a train station, approach routes and shopping streets.
- The city of Ghent has a macroscopic traffic simulation model and a GIS-section within the mobility department.

A map of the case study is shown in annex 6.3.

The case study is divided in four areas:

- The area around the old ARBED-site is bounded by the river Scheldt in the North, the “Brusselsesteenweg” in the West, the highway “E17” in the South and E. Blockstraat, Kerkstraat, E. Hielstraat and Braemkasteelstraat in the East. All the streets in-between are incorporated in the research.
- Brusselsesteenweg
- Land van Rodelaan - Braemkasteelstraat - E. Hielstraat-Kerkstraat
- F. Burvenichstraat
- Kliniekstraat

4.2 Definition of selected typologies

Based on various literature findings on road categories, spatial planning and traffic design and our own expertise in spatial planning and mobility planning, we provisionally distinguish 14 major road types or environments. Some of these major types consist of subtypes. All types are characterised by specific traffic related and spatial features and their function.

We consider the following types in this first draft typology:

- Type 1:
  - 1.a: motorway: road exclusively reserved to fast traffic, with separated lanes and fly-over junctions, indicated by the traffic sign F5
  - 1.b: highway: road exclusively reserved to (fast) motorised vehicles with a speed of at least 40 km/h, indicated by the traffic sign F9
  - 1.c: expressway: (almost) highway with level road-junctions
- Type 2:
  - 2.a: ring-road: road that partially or completely surrounds the city or the build-up area
  - 2.b: traffic diversion road: road built to relieve another busy road
- Type 3: roundabout (big intersection)
- Type 4: approach road: road that leads from a big traffic route to an urban area
- Type 5: ribbon development:
  - 5.a: ribbon development with housing: terrace housing along main roads, open space behind the houses
  - 5.b: ribbon development with shops: big shops fitted well together along busy main roads
- Type 6: throughway: a major road (regional road) that crosses a build-up area:
  - 6.a: wide, straight throughway
  - 6.b: narrow, winding throughway
- Type 7:
  - 7.a: urban axis
  - 7.b: boulevard: long, wide major road, usually planted with rows of trees, with large footpaths, well illuminated
  - 7.c: public transport axis
- Type 8: main roads in cities or villages:
  - 8.a: main road
  - 8.b: old throughway: throughway that has been relieved from busy traffic by a diversion road
- Type 9:
  - 9.a: street in the centre of a city or village
  - 9.b: car-free shopping street
- Type 10: collecting street in a residential area
- Type 11: service road:
  - 11.a: service road for housing
  - 11.b: service road for industry and companies
- Type 12:
  - 12.a: street in an urban residential area
  - 12.b: street in a rural residential area
  - 12.c: street in an allotment
  - 12.d: street in a slow traffic area (30 km/h), infrastructure not adapted
  - 12.e: street in a slow traffic area (30 km/h), infrastructure adapted
  - 12.f living street: part of a residential area where the traffic is restricted, indicated by the traffic sign F12a
- Type 13: transfer junction: node for different means of transport
- Type 14: square
  - 14.a: urban square
  - 14.b: village square

In annex 6.3.2 a table shows the relationship between the different types and the Flemish road categorisation.

4.3 Output format of traffic modelling results

In this study, we simulate traffic flows in Gentbrugge, with the microsimulationmodel Paramics. First, we try to simulate realistic flows as they occur in the present. Later on, we will also simulate flows in scenarios with a different traffic situation.

Traffic flows are already simulated in a small part of Gentbrugge: the Louis Vanhouttestraat and his crossings with the Kerkstraat and the Oude Brusselsesteenweg.

In the model, on each street, we place a detector every 10 meters. These detectors are carefully defined in order to easily identify their location.

After putting in the infrastructure, we also bring in a time-dependent demand of traffic. We need to notice that in this stage, the demand is not yet based on counting results. For the time being, we use an imaginary demand. Finally, we also bring in some properties of the vehicles and those of their drivers. Then the model assesses the movements of each vehicle, resulting in a simulation of traffic flows.

During simulation, each detector registers a series of data for each vehicle that passes the detector:

- The time of passing
- The type of vehicle that passes the detector
- The velocity on that particular moment
- The acceleration on that particular moment

That is, briefly, the output format, coming out of the simulationmodel. Now, one can see the profits and interests of the microsimulationmodel. The output is quite detailed. In order to describe accurately noise and emission effects, it is indispensable to establish these effects on a micro-level. Driving behaviours, velocities, accelerations, etc... are very important when modelling these effects. Therefore, it is necessary to use a simulationmodel that takes these effects into account.

4.4 Definition of common vehicle types

On basis of the needs of the project partners modelling the traffic flows, calculating the tail-pipe or noise emissions, a common categorisation of the vehicle types is set up. This harmonisation was required as each partner is used to work with a specific way of characterising the vehicle fleet within his field (tail-pipe emissions: see 3.4.1.2 – noise emissions: see 3.5.1).

Factors that needed to be taken into account were ease of integration, availability of data and expandability. The vehicle types will be directly used as individual types in the micro simulation model where the difference in power and weight will cause a different behaviour and hence will model a more realistic traffic flow.

After careful consideration the vehicles were divided into following categories:

Main type	**Petrol**	**Diesel**	**LPG**	**Electric**	**Hybrid**	**Natural Gas**
Passenger car	< 70 kW	< 75 kW	< 65kW	X		
	70 kW -100 kW	> 75 kW	65 kW - 90 kW			
	> 100 kW		> 90 kW			
Minibus	X	X	X	X		
Light van	X	X	X	X		
Heavy duty (Freight)		3,5 t – 7,5 t				
		7,5 t – 16 t				
		16 t – 32 t				
		32 t – 40 t				
Heavy duty (Person)		Coach			Trolley	X
		City bus				
Motorcycles	< 50cc					
	> 50cc					
Bicycle						

Within every discipline, the partners weighten the emission factors for all other parameters, not considered within this fleet characterisation, but relevant for a further subdivision, such as vehicle standards.

Although they have no emissions bicycles were also included because they can change the traffic flow. With the scenario computations in mind, alternatives for common used fuel types are foreseen.

4.5 Common Meteo data

Meteo data suitable for the area under investigation has been obtained. Data of five years of meteo observation has, been used to calculate de wind direction on 30m and 50 meters of altitude. At different wind speed the wind direction on 360 degrees has been calculated. For the use of these data in the simulation, modelling of the wind speed at 10 meters above the roof levels of the houses, have to be performed for the use with the “Streetbox model” and “OPSM model“. The data will be added to the common database information side.

The necessary meteorological data can be modelled or obtained from the Meteorological Institute. However, since there are 3 VMM measurement sites in the vicinity, we prefer to use those. The measuring station, at the Baudeloo park (R701 and M701) could be used as “urban background”. Alternatively Prof. Maenhout could provide data for a station south of Ledeberg.

Modelling the meteo requires much computer time and does not offer many advantages for our project because meteorological data for the 2010 scenario are unknown.

RUG will use the same meteo data for the calculation of noise propagation. To this end Vito will provide a detailed frecuency matrix of windsspeeds that will be later aggregated to 8 classes by RUG. Consistent temperature data will also be used to estimate evaporative emissions of vehicles.

To calculate concentration of pollutants in streets background concentrations are needed. In the study area, there are 4 measuring stations that could provide this data (R701, R740, R721, R731). Measurements can also be used to validate the models for specific episodes. Two typical meteorological situations, several days long, will be analysed, one for winter and one for summer.

4.6 Consistent population at-risk map for night-time exposure & Application of health-impact functions

Maps of where people live are a proxy for real exposure. The difference between static and dynamic exposure is clear from the "population-at risk map for night time exposure". Information on exposure is partly derived from literature, partly from measurements. Measurements of night-time traffic PM, and some first monitoring trials of indoor and in-car exposure have been done.

Based on the exposure data (population maps, and pollutant concentration data), the attributable number of cases can be derived. Exposure-response functions from literature are used, and –where possible- detailed health data for Flanders for the different health effects considered. Methods to adapt exposure-response functions to the exposure as calculated in the project (i.e. based on different micro-environments, time activity patterns etc.) are being explored.

We will then calculate impacts for different sets of people (children, elderly), for different specific locations and for school/work-days versus nights and weekends.

4.7 Noise

4.7.1 Dynamic Emissions

The traffic model using micro simulation provides information on where the vehicles are located and what their speed and acceleration is. On basis of the vehicle type and the speed the instant sound power level for the individual vehicles is computed for the given road surface. This information is aggregated to associate an emission level with each road segment. Corrections based on acceleration/deceleration will be included later on. The output from the computations is used to build the generalised emission model. INTEC is now implementing this model.

4.7.2 Generalised Emission Model

Fuzzy Set techniques are used to build the generalised emission model. The model accepts geographical properties of the environment and information about the type of traffic on the road under investigation. A set of fuzzy rules then compares the given environment with the samples stored in its database. The environments most resembling the samples are combined in a non-linear way to produce a prediction of the traffic dynamics and hence sound emission dynamics.

The comparison is done by using a fuzzy measure of the distance between the input and the samples stored in the database. Depending on the resemblance one or more samples can be chosen to combine into the final output of the model.

Although this model was investigated theoretically, no real traffic simulation were used to date since the micro-modelling of traffic is not fully operational yet. The categories used to describe the environment were defined commonly between partners (see Langzaam Verkeer).

4.7.3 Propagation

A propagation model is implemented based on the ISO9613-2 model extended where applicable with the Nord2000 model. More specific explicit support for sideways diffraction is incorporated in the model. The propagation module is fully separated from the emission module and allows for reuse of propagation computations into scenarios.

The propagation model needs to be fed with paths from source to receiver. The technique chosen is object precise polygonal recursive beam tracing in 2.5 dimensions. This means that the simulated world is flat with boxes placed on it. 3D tracing is too computational expensive for the scale of regions that are of interest. Diffraction is only included in shadow regions because diffraction into the direct sound field is insignificant.

This model is already fully operational and currently under test, which means that INTEC is slightly ahead of schedule here.

4.7.4 Uncertainty and low quality data

The complex geo-referenced input resulting in emission and immission maps looses credibility because of lacking or poor quality input data and model approximations. The uncertainty resulting from the simulation process is not neglectable and is explicitly taken care of. Two frameworks are used and compared to model the uncertainties involved in the process: a Fuzzy Sets and a Probabilistic Monte Carlo framework.

The emission and propagation modules are built on the framework of fuzzy calculus to easily swap between the frameworks which makes a direct comparison relative simple. At the input side, the correct semantics of the uncertainty has to be translated in a corresponding distribution in the respective frameworks. Once this is done, the models compute the emission and immission maps while propagating the uncertainty throughout the simulation. Early results suggest that both frameworks lead to qualitatively equal results near emission sources. In a many source environment with almost equal strength sources, the fuzzy approach tends to report more uncertainty further away from the sources. The reason is that information propagates differently through the different frameworks and is dependent on the amount of mathematical operations and what type they are.

The fuzzy set approach proves a useful alternative to a Monte Carlo simulation and has the tremendous advantage of being several orders faster.

5. Future prospects and future planning; Milestones for 2003

5.1 Expanding the geographical scope of traffic modelling
5.2 Objective and subjective criteria for liveable cities (Questionnaires)
5.3 Dynamic tailpipe emission factors for 2002 and 2010
5.4 First modelling results from Aurora as well as from the local StreetBox model
5.5 Population at-risk maps for rush hour and day-time exposure
5.6 First indoor impact calculations
5.7 Extended emission factors for noise (Expanded number of road and pavement types)
5.8 Micro-scale noise propagation model

6. Annexes

6.1 References

6.2 Publications (limited to subjects related to this project and actually published in 2002)

6.2.1 LV

6.2.2 KUL

Immers B. en B. Egeter, “OWN als redmiddel tegen verkeersinfarct”, Verkeerskunde 2 / 2002.

Immers B., Stada J., en I. Wilminck, “Zuid-Holland ontvlecht” Verkeerskunde 3 / 2002.

Logghe S. and B. Immers, “Heterogeneous traffic flow modelling with the LWR model using passenger-car equivalents“ Working paper ‘verkeer en infrastructuur’, 2002.

6.2.3 RUG

A. Verkeyn, D. Botteldooren, "Towards language independent models based on survey data", Proc. of the IEEE World Congres on Computational Intelligence (WCCI) 2002, Honolulu, Hawaii, May 2002, pp. 1063-1068 (and CD-ROM, Paper 4117)

A. Verkeyn, D. Botteldooren, "Annoyance prediction with fuzzy rule bases", In: Computational Intelligent Systems for Applied Research: Proc. of the 5th International Fuzzy Logic Intelligent technologies in Nuclear Science (FLINS) Conference, D. Ruan, P. D'hondt, E. Kerre (eds.), Het Pand, Ghent, Belgium, Sep. 2002, pp. 411-418

A. Verkeyn, D. Botteldooren, "The effect of land-use variables in a fuzzy rule based model for noise annoyance", Proc. of the 31th International Congress on Noise Control Engineering (Internoise) 2002, Dearborn, Michigan, USA, Aug. 2002 (on CD-ROM, Paper 371)

D. Botteldooren, A. Verkeyn, "Aggregation of specific noise annoyance to a general noise annoyance rating: a fuzzy model", Proc. of the 9th International Congress on Sound and Vibration (ICSV), Orlando, Florida, USA, Jul. 2002 (on CD-ROM)

D. Botteldooren, A. Verkeyn, "Fuzzy models for accumulation of reported community noise annoyance from combined sources", J. of the Acoust. Soc. of America, 112 (4), 2002, pp. 1496-1508

D. Botteldooren, A. Verkeyn, P. Lercher, "Noise annoyance modeling using fuzzy rule based systems", J. of Noise and Health, 15 (4), 2002, pp. 27-44

D. Botteldooren, A. Verkeyn, C. Cornelis, M. De Cock, "On the meaning of noise annoyance modifiers: a fuzzy set theoretical approach", Acta Acustica united with Acustica, 88 (2), 2002, pp. 239-251

D. Botteldooren, A. Verkeyn, "An iterative fuzzy model for cognitive processes involved in environment quality judgement", Proceedings of the IEEE World Congres on Computational Intelligence (WCCI) 2002, Honolulu, Hawaii, May 2002, pp. 1057-1062 (and CD-ROM, Paper 4116)

L. Dekoninck and D. Botteldooren, “Prediction of noise annoyance due to local traffic using geographic information and traffic modeling”, Proc. of the 31th International Congress on Noise Control Engineering (Internoise) 2002, Dearborn, Michigan, USA, Aug. 2002 (on CD-ROM, Paper 295)

T. De Muer, D. Botteldooren, "Fuzzy Noise Maps", Proc. of Forum Acusticum 2002, Sevilla, Spain, Sep. 2002 (on CD-ROM, NOI-06-007)

6.2.4 Vito

L. Int Panis, A. Rabl, L. De Nocker, R. Torfs, 2002. Diesel or Petrol? An environmental comparison hampered by uncertainty. Proceedings of 11th International Symp. Transport and Air Pollution. *Mitteilungen Institut für Verbrennungskraftmaschinen und Therodynamik*. Ed. P. Sturm, Technische Universität Graz, Austria. Heft 81, Vol 1, p 48-54.

Mensink, C., Colles, A. Janssen, L and Cornelis, J.
Integrated air quality modelling for the assessment of air quality in streets against the Council directives, *Proc. 11th International Scientific Symposium Transport and Air Pollution*, in: P. J. Sturm, S. Minarik (eds.) VKM-THD Mitteilungen Volume 81, pp. 131-138, Graz, June 2002

Mensink, C., Lewyckyj, N. and Janssen, L., 2002. A new concept for air quality modelling in street canyons, *Water, Air and Soil Pollution: Focus* 2: 339-349, Kluwer Academic Publishers

Cornelis E., De Vlieger I. & Int Panis L., Emissions of mopeds and motorcycles in Belgium, 2002. *Urban Transport VIII, Urban Transport and the Environment in the 21st Century, (Editors: L.J. Sucharov, C.A. Brebbia & F. Beeitez),* pp. 491-500, ISBN 1-85312-905-4, WIT Press, Southampton, 2002.

Mensink, C., Colles, A., Janssen, L. and Cornelis, J., 2002. Environmental impact assessment of air quality in street canyons related to Council directives 1999/30/EC and 2000/69/EC, in: E. Batchvarova and D. Syrakov (Eds.) *Proceedings of the 8th Int. Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes,* Sofia, Bulgaria, 14-17 October 2002, pp. 292-296.

L. Int Panis, L. De Nocker, E. Cornelis, R. Torfs, 2002. An uncertainty analysis of air pollution externalities from road transport in Belgium in 2010. submitted to Science of the total environment, Proceedings of the 7th Highway and Urban pollution conference.

Rudi Torfs en Greet Shoeters, 2002. Inhaleerbaar stof – kleine deeltjes, groot risico? Stichting Leefmilieu, MILIEUFICHE 2002 – 3, http://www.argusmilieu.be/NEO/middenkrant/Alles/2002_stof.htm#Inleiding

6.3 Detailed results

6.3.1 The case study area in Ghent

Figure 1 shows the map of the case study.

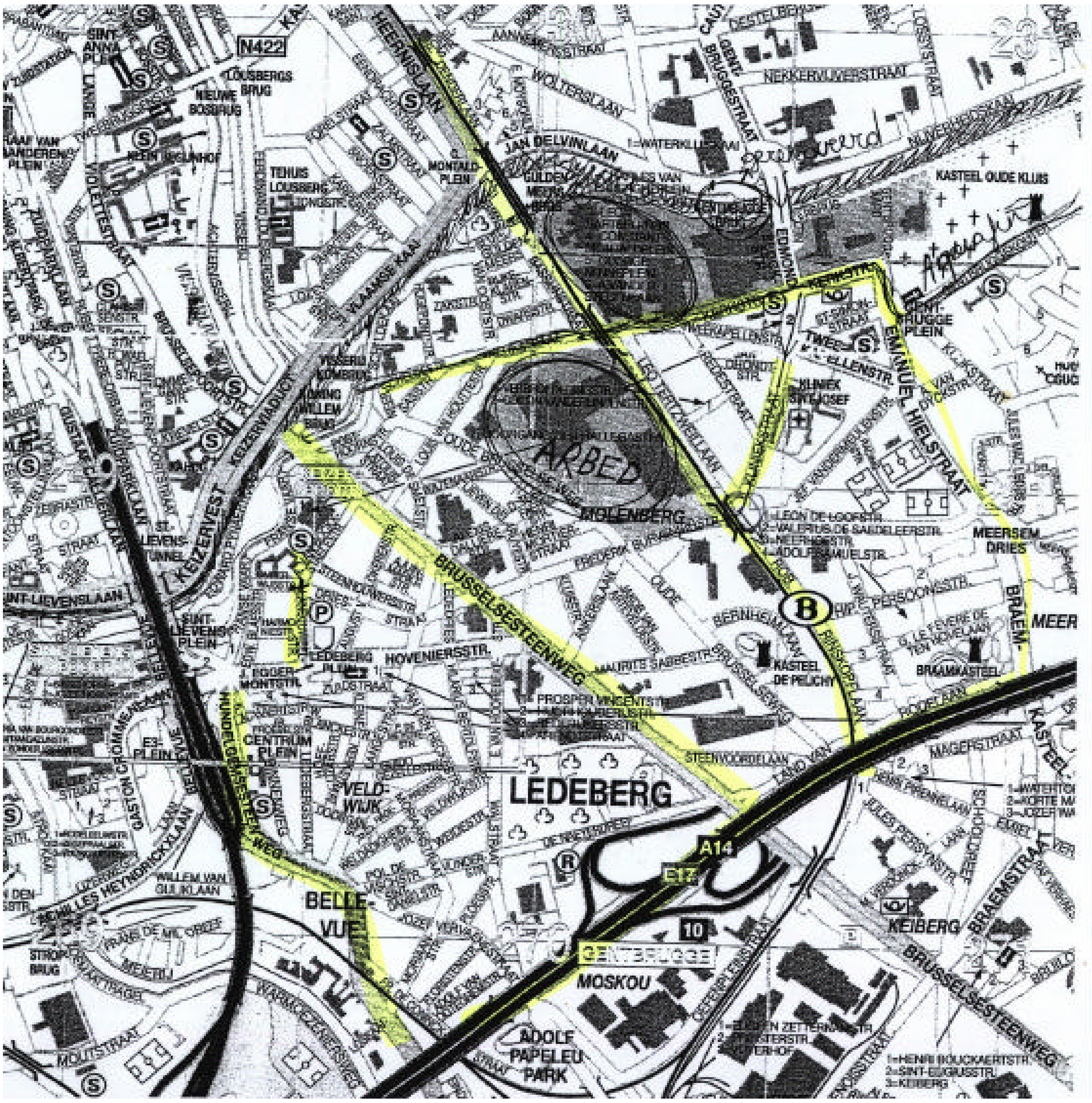

Figure 1: the map of the case study Gentbrugge/Ledeberg.

6.3.2 Relationship between the main types of roads and the Flemish road classification

		Main types													
	Name of category: function of the road	**1) highway(a), motorway(b), expressway(c)**	**2) ring-road(a), traffic diversion road(b)**	**3) roundabout (big intersection)**	**4) approach road**	**5) ribbon development: housing(a), commercial(b)**	**6) throughway: wide and straight(a), narrow, winding(b)**	**7) Axis: urban(a), boulevard(b), public transport(c)**	**8) main streets: in city(a), village(b)**	**9) street in centre of city or village(a) car-free shopping street(b)**	**10) collecting street in residential area**	**11) service road: housing(a), commercial or industry(b)**	**12) residential streets(a/c), roads in slow traffic area, zone 30km/h(d/e), living street(f)**	**13) transfer junction**	**14) squares: town(a), village(b)**
Classification	**European highways**	x	x	x											
		x	x	x	x										
	primary road type I: connect on Flemish scale	x	x	x	x										
	primary road type II: collect on Flemish scale		x	x	x	x	x	x	x						
	secondary road type I: connect but not on Flemish scale		x	x	x	x	x	x	x						
	secondary road type II: collect on small-town scale			x	x	x	x	x	x						
	secondary road type III: collect rural areas				x	x	x	x	x						
	secondary road type IV: former connecting function on Flemish scale							x	x	x	x	x	x	x	x
	local road type I: connecting road							x	x	x	x	x	x	x	x
	local road type II: opening up an area							x	x	x	x	x	x	x	x