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Road and Rail Infrastructure II

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MODELLING THE IMPACT OF TRAFFIC ON QUALITY OF LIFE: SCENARIO EVALUATION FOR THE CITY OF GHENT

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Abstract

Traffic influences the people's quality of life in various ways, both in a positive as in a negative sense. Traffic is inevitable in order to guarantee people's accessibility to various types of functions. On the other hand, traffic noise, traffic emissions, road safety, threatens people health and well–being. Because quality of life is more and more under pressure, because of the increasing traffic flow, traffic livability has become a key issue in nowadays' (Flemish) traffic planning.
Therefore, it is remarkable that little research has been done about assessing the total impact of traffic on the quality of life of the surrounding areas. Methods that are currently commonly used in Flanders have some important restrictions; the most crucial one is that the impact of traffic is considered to be very local. This is remarkable because people's quality of life depends on the whole living environment, covering a wider area.
For this reason, a project was set up by the Flemish Policy Research Centre Mobility & Public Works in order to develop a model to give a better representation of the impact of traffic on quality of life. The main focus was to achieve a better simulation of people's exposure to different types of traffic impacts by including not only the exposure at the home address, but also the impacts during activities at other locations and the impacts during trips.

Keywords: urban traffic, livability, quality of life, travel behaviour, traffic noise, traffic emissions

1 Introduction

Within the frame of the Flemish Policy Research Centre Mobility & Public Works a model was developed, aiming at a better assessment of people's perception of traffic annoyance in their living environment. The reason is that existing methodologies show intuitive shortcomings: for example most indicators are related to the road characteristics and traffic data (and not to people's exposure and perception) and only traffic impacts on the home location are taken into consideration (and not in the rest of their living environment).
Therefore, the main focus in the proposed methodology is to achieve a better simulation of people's exposure to different types of traffic impacts, in order to measure not only the exposure to traffic annoyance at the home address, but also the impacts during activities at other locations and the impacts during trips. This is achieved by simulating the individual activity patterns of the population within the study area. By evaluating each individual's exposure to different types of traffic impacts during his trips and activities (both at home and at other locations), a better representation of people's quality of life can be expected.
In different phases of the project, first a theoretical model has been developed for measuring the impact of traffic on living quality. In the second phase this theoretical methodology was

implemented in a model application, which was finally applied to a case–study for the city of Ghent. The model's possibilities were shown in a number of practical applications. This paper describes the results of some scenario evaluations, illustrating the impact of traffic behaviour on people's perception of the traffic impact.

2 Model description

2.1 Selection of an indicator set for 'traffic livability'

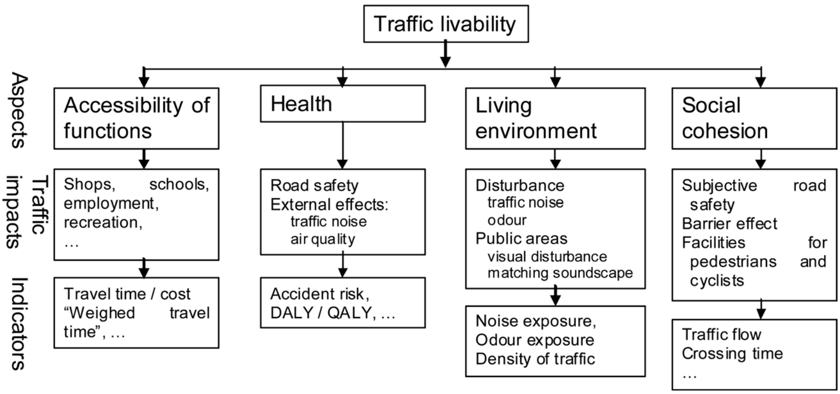

Figure 1 Definition of traffic livability, containing several types of traffic impacts, each with their own indicators

Existing methods split down the 'traffic livability' into separate types of traffic impacts, and define a set of indicators for each of them. The proposed model will follow the same structure, with a similar set of indicators. The main innovation is that indicators are chosen in order to reflect people's perception of traffic annoyance, rather than pure traffic data or road characteristics. For example, the quality of bicycle infrastructure is not indicated by width, but by a score indicating how well the infrastructure meets the design criteria.
The indicator set is based on a literature review concerning 'traffic livability', and related terms like 'quality of life' or 'living quality'. This resulted in a breakdown of the term into four components: accessibility of basic functions, health impact (as traffic emissions, sleep disturbance, etc.), effects on environment (noise annoyance, visual impact, etc.) and effects on the social functioning of the neighbourhood (barrier effect, etc.). Each component is divided into some partial effects with their specific indicators. Measuring traffic livability will be realized by measuring these indicators and aggregating them to a global score for each component and for the total traffic livability.

2.2 Methodology for the evaluation of the indicators

The main shortcoming of the existing methodologies for measuring the traffic livability is the (over–) simplified way of evaluating the indicators. The living quality of an address is considered to be determined by the traffic impacts at this very specific location: the local noise level, local air quality, etc, as if making a simple overlay of several layers.
In order to reach a better representation of the neighbourhood perception, an alternative methodology was developed, with the following characteristics:

- Traffic livability is measured by means of a broad set of indicators, representing different types of traffic impacts (accessibility, traffic noise, traffic emissions, etc.).
- The evaluation is not done for an average person, but takes into account individual needs and travel patterns, sampled from the Flemish large–scale trip survey (The Flemish Trip Be-

haviour Survey – Onderzoek VerplaatsingsGedrag, OVG), a large scale survey collecting trip data by means of trip diaries covering the whole of Flanders. The survey data consists of three data sets containing the family characteristics, the person's characteristics and the personal trip data. The survey has been executed in 1994–1995 (OVG-1), in 2000–2001 (OVG-2) and in 2007–2008 (OVG-3) (Ministerie van de Vlaamse Gemeenschap, 1996, 2004, 2009), each covering about 8.000 persons. This means that personal characteristics (age, marital status, professional activities, etc.) and family characteristics (number and age of children, car availability, etc.) and the consequent diverse mobility needs, are incorporated in the evaluation.
- The methodology reflects the daily activity pattern and the trip pattern. Beside the traffic impacts at home, also the effects during the trips and at the destinations are included in the evaluation. This means that the evaluation of traffic livability covers the complete living neighbourhood, rather than limiting it to the dwelling itself or the street it is located in.

These characteristics are reached with a Monte Carlo simulation method of, sampling random families and/or persons from the Trip Database of the Flemish Trip Behaviour Survey, and consequently sampling a logical destination from a set of pinpoint locations. The traffic livability of a dwelling location is then evaluated in the following steps:
- First of all, a random household is sampled from the Trip Database of the Flemish Trip Behaviour Survey. In the database a large set of characteristics are available about the household (composition, car availability, etc.) and its members (age, income, etc.) and their specific daily trips (number, purpose, distance, etc.).
- For all the trips that are reported by this household, the following step is to select a logical destination. This destination is again sampled from a database of possible destinations per trip purpose. For school trips a nearby school is selected, for shopping trips a shop, etc.
- For the collected trips, travel modes and destinations, the third step is to calculate a logical route from the dwelling to the destination.
- Knowing the dwelling location, destination locations, routes and transportation modes of all the trips and activities of each household member, it is possible to make the evaluation of this person's perception of the traffic impacts at home, during the trips, and at the destinations.

By sampling a sufficient number of dwellings per street segment (or a sufficient number of households per dwelling), this method results in an aggregated perception of traffic livability, representing a realistic variety of activity patterns and transportation needs and covering the complete living space of the population, rather than just the dwelling location. The expectation is that this will better reflect people's perception, as stated in surveys or interviews.

2.3 Global model structure

The sampling of households and their activity and trip pattern is only a part –albeit the most innovative part– of a larger model structure, which is represented in the following scheme. As indicated, the model consists of four major parts:
- the input GIS layers and databases, containing attributes about the infrastructure, traffic, dwellings, points of interest, and demographic statistics about trip behaviour and time usage;
- the exposure simulation, containing the simulation of individual activity and trip patterns, and the resulting exposure to traffic impacts (noise, air pollution, traffic safety risks, etc.);
- the traffic model, generating the overall traffic flows and traffic characteristics (such as traffic speed and congestion), which are used to derive traffic noise immissions and air pollution maps, evaluate safety risks, etc;
- the indicator aggregation module, where the results from the individual indicator evaluations are aggregated geographically (grouping individuals to a street or neighbourhood level) and/or thematically (grouping indicators to a thematic score and a global livability score).

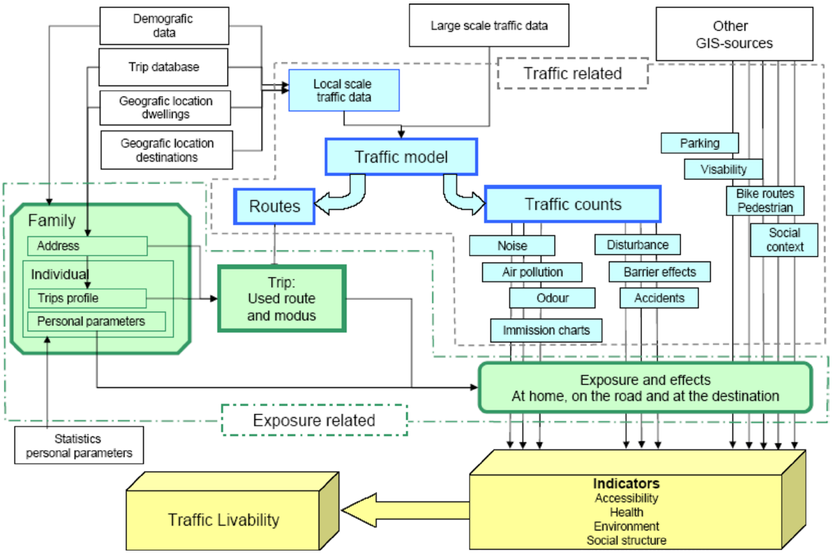

Figure 2 Global structure of the traffic livability model

3 Basic model applications

3.1 Traffic livability maps

The presented model has been applied in a case–study for the Belgian city of Ghent. This case–study illustrates some of the model's possibilities. The most obvious application is the evaluation of the current traffic livability. Several statistics can be used to measure the quality (the average traffic livability evaluation, but also percentile values representing the better or poorer individual appreciations, etc.). Histograms can be used showing the distribution of the population's scores, or maps showing the geographic spread of the scores.

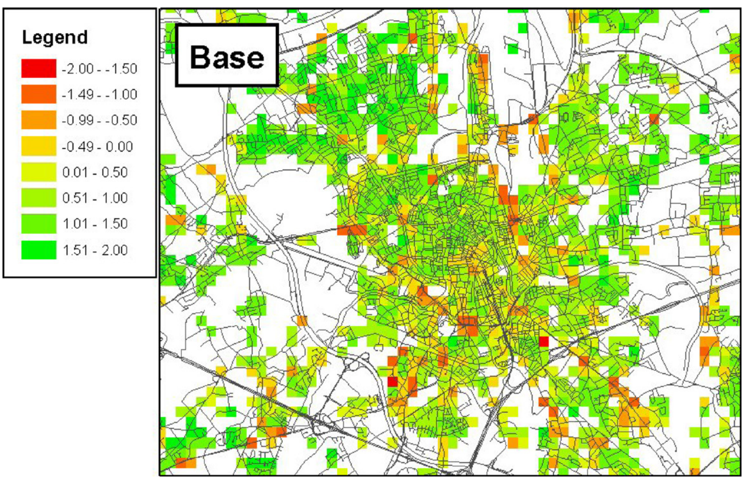

Figure 3 Model plot showing the average traffic livability using a 200m raster aggregation

Calculations for the current livability of the traffic in Ghent have shown realistic results. In geographic sense, problem areas are detected corresponding to the real problem areas, as reported in policy documents,but also reported appreciation, based on a large–scale survey about people's satisfaction with their living environment ('Schriftelijk Leefomgevingsonderzoek') is reproduced in a satisfying way.
Apart from the global score, the model also has further explanatory value, as further detail is available about the separate indicators. The model does not only show areas with good or bad traffic quality, but also explains why specific areas have better or poorer evaluations. In terms of transportation policy, the model does not only show the problem areas, but also enables further analysis on the type of measures that is needed (aiming at improved traffic safety, traffic noise, etc.).

3.2 Scenarios on traffic behaviour

Based on the model of the current situation, derived scenario's can be evaluated. This means that the traffic livability is recalculated, taking into account some modifications to the model input. These modifications can deal with the urban structure, the transportation network and the traffic behaviour (or a combination of these three).
Changes in the urban structure lead to a different spread of home locations and of functions in the neighbourhood. In the model this leads to a different evaluation of traffic livability, as people may change their destination choice if they can choose from more or less possible functions. Practical applications are for example the livability evaluation in new housing areas (how will inhabitants perceive the traffic annoyance in their neighbourhood?) or the impact of new shopping areas (e.g. a situation with an increase of more small–scale local shops, opposed to a situation with a limited number of large supermarkets).
Modifications to the transportation network may include the addition or removal of roads for specific travel modes (leading to more or less dense networks) or adapted speed limits. These measures influence people's mode choice and route choice, which again has a double effect: it changes their exposure to external traffic impacts, but also their own traffic emissions to the environment. For example, a modal shift from car to bicycle has the positive effect of eliminating a car trip and the resulting traffic noise, emissions, traffic unsafety, etc. But a second positive effect is that route choice by bike rather follows the shortest route (opposed to following the fastest route by car), and therefore uses a more quiet road with lower exposure to traffic noise, traffic emissions, etc.
At this moment, changes of the traffic behaviour are incorporated only in an indirect way, as the model is now based on a simulation of the reported activity patterns and the reported trip behaviour. Therefore, the methodology focuses on correct reproduction of reported behaviour. Changes to the behaviour are only possible by modifying the database of reported behaviour, for example by modifying the number of trips (for specific modes of purposes) or by changing the reported mode choice for certain trips.
Results of several scenario evaluations can be found in [4] and [7].

4 Conclusions

The proposed model has already been applied in several applications, both for analysing the current situation, as for the scenario evaluation. The results show a good reproduction of the real (reported) satisfaction about (the traffic impact on) people's living environment. Also scenario results show intuitively correct effects on the traffic impacts. This is mainly true for scenarios with relatively modest adaptations in regard to the current situation. However, in case of more radical scenarios, some of the limitations of the current model become clear. The most crucial limitations are:

- For a large number of indicators, external maps are imported as base data, for example air quality maps by the Flemish government are used. In radical scenarios, the radically changed travel behaviour (e.g. modal shift from car to other modes) results in changed exposure, which is fully incorporated in the model. However, there is secondary effect, as this modal shift results in lower traffic intensities, and thus in lower traffic emissions. Including this secondary effect in the model would require a recalculation (re–iteration) of the initial air quality map, based on the decreased traffic flows.
- In chapter 3.2 the possible contents of scenarios are described as three independent types of modifications (urban structure, transport network, travel behaviour). However, in case of thorough changes to the urban structure or to the transport network, the impact may result in an adaptation of people's travel behaviour: a reduced (or improved) accessibility may lead to a decreased (or increased) mobility. At this moment, this link is not included in the model, as travel behaviour is considered to be an independent input.

These limitations define the future challenges for further development of the model:

- The recalculation of the basic input maps is not a technical issue, as specific software for modelling traffic impacts (noise, emissions, etc.) is available. Coupling our model with external models would be a technical solution, although the procedure for evaluation of a scenario would be cumbersome if several external models need to run to produce the inputs for the traffic livability model. Therefore, more straightforward alternatives are required.
- The current model is strongly based on a simulation of the reported behaviour. In case of a more radical scenario, which influences the individual travel behaviour (either trip generation, mode choice, destination choice, etc.), one would want the model to automatically incorporate these changes. Therefore the inclusion of an individual travel choice model would be a major asset, estimating the impact of changing accessibility on the individual trip behaviour.

Especially this second challenge will be the subject of further elaboration of the model.

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