Mobility Transition & Quality of Life (MobiLe)– The development of a qualitative model for conveying significant interdependencies in the complex transport system

Sreedhar Kokkarachedu and Jorge Marx Gómez

Abstract Nowadays, sustainable urban development plays a key role in improving the life quality of people. This can be achieved through mobility transition. So, Municipal politicians need to take transport-related decisions toward sustainability. This research mainly aimed to provide novel decision-making aid for municipal politicians to better understand and consider the complexity and interdependencies of the municipal transport system. This enables local politicians to assess the complex effects of traffic-effective decisions independently and at an early stage. For this, a web app is developing as easy-to-use software.

Key words: Urban Development, Mobility, Web-based Planning Tool, Municipal Transport Systems, Cybernetic Model, Mobility Transition

1 Introduction

Mobility transition is necessary for the context of sustainable development [1], but so far been only insufficiently initiated [2]. Many positive effects, such as reduced air and noise pollution, reduced consumption of land and other resources, and the positive health effects of active exercise, can be achieved through environmentally friendly transportation systems[3][4]. This fits into the concept of ”cities for people” [5], which have a high quality of life and thus attractiveness. Copenhagen is the example where this principle was first applied. Therefore, it is crucial to reorient mobility towards sustainability, notably in local mobility at the municipal level,

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whose importance for the transport transition is emphasized in the current version of the German Sustainability Strategy [6].

On another hand, the complexity of the transport system is a difficult challenge in mobility transition. Participation in traffic is commonplace for almost all people, but many people underestimated this complexity and have their own experiences. Moreover, the decision-makers do not fundamentally differ from the general population. Therefore, it is necessary for a mobility transition to enhance the understanding of system interrelationships, by ”laymen” in decision-making positions. This understanding must be so certain that system relationships can be easily communicated to the population – both by the politicians and by the administration. For this purpose, MobiLe is intended to develop a suitable support that clarifies system correlations and can be applicable to both known and new elements of the municipal transport system. MobiLe provides a knowledge-based approach as a further basis for decision-making, which supports a mobility transition argumentatively.

If the expectations in this approach of ”political consulting” are fulfilled, then the politicians of all political groups use MobiLe to prepare their political deliberations and decisions. They can add all the measures they want over the seven parameters in this dynamic mathematical model, look at the result of the simulation and check it against their policy objectives.This process is clearly described in Sect. 2. If these are fulfilled, MobiLe serves as a crucial decision tool. If these are not yet achieved, the analysis functions can be used to understand where the system behaves unexpectedly and is effectively influenced. Even if this analysis step is not used (in each case), new simulations can be carried out quickly by changing the control variables, so that optimization can also be achieved playfully. One of the prerequisites for success will be that the application of this tool should be fast due to the political work is already very time-consuming for voluntary local politics.

2 Mathematical Modell

The development of the cybernetic, qualitatively oriented model takes place in the project ”Mobility Transition & Quality of Life”, which is currently being funded by the BMBF as part of the MobilityWerkStadt 2025. For a qualitative mapping and analysis of traffic relationships and developments, system-dynamic sensitivity models [7][8] are already used in research projects in transport and spatial planning [9][10][11][12]. The advantages of these models are the comparatively low data effort and the high traceability by the decision-makers [11][13].

MobiLe is also developed using the sensitivity model [14]. This makes it possible to include aspects of life linked to the (traffic) system, as well as a cybernetic analysis of the resulting interactions [15]. This enables the qualitative consideration of the consequences in the municipal environment, which has been lacking in previous transportation models. As a result, it is feasible to evaluate system changes in a temporally dynamic manner and assess their qualitative influence on the system.

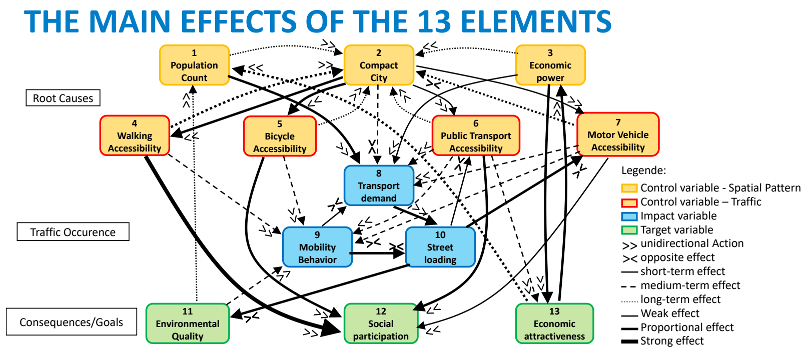

Fig. 1 Basic model for MobiLe for the entire city, as of June 2022

The basic urban model consisting of 13 elements - based on the sensitivity model of Prof. Vester - will be further developed. which can be further subdivided into control, impact, and target variables. The integration of an economic component is being examined, and the test schemes for all 7 control variables are being expanded to include city-wide planning. For each of these elements, it was examined what influences it could have on other elements. In doing so, not only was attention paid to whether there were influences. In addition, assessments were made as to how strong these influences are, whether they are counter-directional or unidirectional, and over what period of time the influence takes place. The influences were divided into strong, medium, and weak effects and into short-, medium- and long-term influences.Users can intervene in the system by means of a test scheme for each of the seven control variables. Each test scheme contains different facilitating and inhibiting measures for the respective element. For each of the measures, it is numerically specified whether they have a strong, medium, or weak influence. Based on the sums of the selected measures, a conversion is made into a strong, medium or weak influence on urban traffic, which is then transferred to the simulation by influencing the affected control variable. As a result, the impact of the measures on the thirteen elements is presented.

In terms of the mathematical model, it is also necessary to stabilize the simulation for long-term forecasts concerning the target parameter ”social participation”. The model developed in this way enables an assessment of the consequences of implementing a wide range of measures (combinations) within Norderstedt. The model was developed in a co-creation process. In this process, the administration and scientific partners worked out the basic principles and coordinated them with policymakers in an iterative process.

So far, only small-scale measures have been considered and still, and a practical test is still missing. Subsequently, an extension is planned that considers large-scale measures that affect the entire city as a second application case - such as a new land use plan or a bicycle traffic concept. Since this is a qualitative model, the estimates used are not based on concrete statistics but reflect the consensus from the expert assessment of various transport ecologists and scientists, which is supported as far as possible by literature references. This will subsequently be extended to the public. A side effect of this should be to gather and incorporate more information as early as possible to increase the quality, acceptance, and usability of the model.

In order to get an insight into the results of dynamic simulations, a simple programming in Excel was carried out as a workaround. This makes it possible to show developments as a sequence of several static simulations, which, in addition to the direct and indirect effects of system interventions, also illustrate how the states of the model elements develop over time. In this way, qualitative impact assessments of higher-level strategies (e.g., a promotion of bicycle traffic) can be analyzed. Even these first simple applications show that the model represents some impacts that are not already intuitively foreseen by everyone. This in itself provides considerable added value. The unexpected statements provide important clues to previously unrecognized relationships and provide a gain in knowledge.

The model is initially designed for the city of Norderstedt. It will be usable for many cities of similar size, largely unchanged. In order to derive the greatest possible benefit from the model, transferability to other municipalities is planned from the outset during development. This has an influence on the programming, which has to be developed as open source. This aspect will be discussed in more detail below.

3 The development of the software

MobiLe is to be developed as a dynamized digital version of the basic model and its customizing options to represent the municipal transport system accurately and at the same time as simply as possible. The development of the model and the associated software will be carried out in the agile development methodology Scrum. For the programming, it was first necessary to investigate which technology was suitable for implementation. Initial research showed the previously used program GAMMA [16] does not have any public source code or interfaces. This requires the development of new software. Therefore, it is aimed to develop and implement the model completely in-house using a well-known and recognized programming language.

The developed software can and should be made available as open-source software to encourage possible adaptations for transferability to other cities/municipalities and to ensure continued use even after the project ends.

The software will be designed as a web application. This allows the application to be accessed via the browser across platforms, especially on smartphones and tablets. There is no need to download or install the web application in advance. Although a good Internet connection is required, the development of the web application usually requires less development and maintenance effort [17]. The expansion of the web application as a Software as a Service (SaaS) solution is conceivable as a future business model[18]. In this SaaS solution, the software and IT infrastructure are operated by an external IT service provider and used by the customer as a service.

Since the software is primarily intended for local government and the population, special attention must be paid to the user interface (UI). What is needed is an intuitive

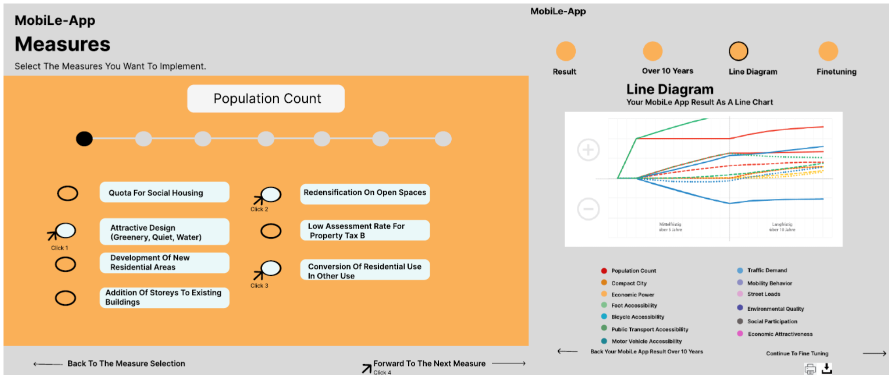

Fig. 2 Web App Design Layout of selecting measures of control variable and displaying influences in a line diagram

and responsive design of the UI. For this purpose, the designs and UI elements will be supplied by an experienced graphic designer (MOSCHDESIGN).

For the development of web applications, different software technologies are used. While the data operations and calculations are performed in the back end, the visualization for this is done by providing the calculation results via the front end, for example in the form of customizable graphs. Both the back-end and front-end communicate via Restful API. By deploying in Docker-based containers, the application can be hosted quickly and without customization on different IT structures.

During the development of the new software, various testing stages are run after a software design is available. Thus, evaluation and testing of the implemented software through unit tests, integration tests, system tests, and acceptance tests will be performed by the user through various workshops with the project partners, to which potential users* will be invited [19].

The developed software will be made available to the project partners at an early stage, still during development. For this purpose, the software versioning tool GitLab is used, which is hosted by the IT services of the University of Oldenburg. Once the software is in its first executable version, a public GitHub repository will also be opened, and the code will be made available to the public for a (test) application. After project completion, the code continues to be available via the repository. In addition, an executable instance can be hosted at the University of Oldenburg. Interested municipalities can set up their instance using the public repository. This step can already be done during the project duration and can be supported by the University of Oldenburg. Support for external persons in editing and adapting the model after the end of the project is conceivable. The type of support depends on the further course of the project and can therefore only be specified at a later point in time.

4 Conclusion

MobiLe will develop an easy-to-use tool that offers the opportunity to support municipal decisions in the transport system and facilitate the assessment of the consequences of decisions through its knowledge-based approach. Before parliamentary deliberations, the input of traffic-relevant measures should be able to be quickly assessed by the modeled preview, which influences they will have on the traffic situation in the city. If the political goals are not achieved, changes can be made to the parameters. This does not restrict the decision-making freedom of politicians, but better consideration of the effects can lead to a better understanding of the complex effects and an adaptation to the findings.

The permanent exchange with policymakers as well as the later involvement of the public will lead to an increased acceptance of the new tool. In addition, the use of the tool beyond the end of the project should be encouraged. The web application, which is made available as open-source software, can thus make a small contribution to the necessary mobility turnaround.

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