TEACHING MATERIAL GUIDANCE

1) Title of the material

Oskarbski, J.; Birr, K.; Żarski, K. Bicycle Traffic Model for Sustainable Urban Mobility Planning. Energies 2021, 14, 5970. https://doi.org/10.3390/en14185970

https://www.mdpi.com/1996-1073/14/18/5970

2) Which section of the SUMP it is relevant to?

This paper presents the methodology for developing a four-stage macroscopic model of bicycle traffic for the city of Gdynia, and its use in planning new bicycle routes, considering a modal shift. Therefore, the article can be linked to the third, fourth, and fifth sections of the SUMP circle related, respectively, to the determination of planning framework, analysis of the mobility situation (in particular the analysis of problems and opportunities for all modes of transport - **Subsection 3.2.**), scenario building and joint evaluation (development of scenarios of possible futures - **Subsection 4.1.**) and vision and strategy development (arguments for stakeholders - **Subsection 5.1**).

3) Which Mobility Manager knowledge this material is the most relevant to?

It is related to Transport and mobility planning (section 1 of the Mobility Manager competencies) especially 1e (evaluation of transport measures) and Data analysis for mobility planning (section 5 of the Mobility Manager competencies) especially 5b (transport modelling and simulation) as well as Stakeholder involvement tools (section 7 of the Mobility Manager competencies).

4) Problem approached and content overview

Problem approach – general understanding of how to model transport system elements and evaluate the effectiveness of planned measures. Modelling tools and transport models are required to assess the impact of measures for the effective planning of cycling routes in cities. This paper presents the methodology for developing a four-stage macroscopic model of bicycle traffic for the city of Gdynia, and its use in planning new bicycle routes, considering a modal shift. The model presented in this paper allows for the evaluation of the influence of the characteristics of the cycling infrastructure, along with the development of the cycling network based on the choice of cycling as an alternative to other modes of transport, by taking into account the modal shift. The model takes into account the influence of the longitudinal gradient, link, and surface type of cycling routes on the distribution and demand for bicycle traffic. The results of our research allow us to assess the impact of planned cycling routes on the reduction in the volume of car traffic, which is crucial for reducing energy consumption and negative environmental impacts. Experiences from the application of the model in Gdynia suggest that the model provides a strong basis to support mobility planning and monitoring processes in cities worldwide. Cities should take into account the methods proposed in this paper when planning the development of their transport systems.

Co-funded by the Erasmus+ Programme of the European Union

TEACHING MATERIAL GUIDANCE

This paper presents an overview of solutions applied in transport modelling, with particular attention to cycling. Measures and factors influencing the modal split, the volume of cycling traffic, techniques of analysis of cycling activity as well as methods of estimating and forecasting the volume of cycling traffic are characterised. Moreover, the methodology of cycling traffic modelling was presented, with particular attention paid to the modelling of demand for cycling and route choice. The use of the modelling methodology in studies on the influence of cycling network development on the demand for transport and distribution of cycling traffic is also presented.

5) Who could be interested in this material?

The article is aimed at students and those looking for inspiration in the use of modelling in the evaluation of transport system effectiveness when such measures are applied in SUMP. Transport models can be used to monitor SUMP Key Performance Indicators.

6) What is worth mentioning as an innovative factor for the reader?

Transport demand models and transport networks that incorporate active travel modes can effectively support the mobility planning process, as demonstrated in this study. Models should be used to evaluate measures implemented in the transport system to determine the impact of these measures on reducing traffic and congestion on the road network and the resulting reduction in energy consumption and emissions. Models allow a better understanding of changes in transport system performance and traveller behaviour under different scenarios of transport system development. However, to make a reliable assessment possible, it is necessary to apply models allowing to estimate the modal shift towards cycling. The model presented in this paper allows us to analyse the influence of the development of the public transport system or road infrastructure on the transport behaviour of inhabitants in terms of changes in the probability of choosing cycling for travel. The model also allows assessing the influence of the characteristics of the cycling infrastructure and the development of the cycling network on the choice of cycling as an alternative to other modes of transport. The application of the presented methodology and tools for transport planning gives a solid basis for the selection of the most effective solutions in the planning process.

As data about times and routes of cycling within the urban transport network are still scarce, direct measurements of cycling traffic - including GPS tracking and data from ITS services - have been used in the modelling. It is important to use a fusion of data from multiple available sources to reduce the cost of the study.

An additional contribution of the research is the inclusion in the model of the influence of the longitudinal gradient on the speed of cyclists, using the GIS environment, and the inclusion of the types of cycling network sections and their surface in the choice of transport mode and route. The model presented in this paper reliably represents the cycling network, taking into account the longitudinal gradients, the type of pavement and the type of cycling connection by defining the speeds on the different sections of the cycling network based on these variables.

Co-funded by the Erasmus+ Programme of the European Union

TEACHING MATERIAL GUIDANCE

The key factor determining the modal split is the travel time of the individual modes of transport. A logit model was used to model the modal split. This model takes into account the utility of individual modes of transport, expressed as a component of two elements: the measurable utility and the random part. The model uses cycling times calculated based on cycling speeds on particular sections of the cycling network.

The proposed approach allows modal shifts between modes to be modelled and estimated taking random factors into account. This feature of the model is important for analyses aimed at determining the degree of reduction of congestion, emissions and energy consumption.

The calculation of cycling flows was carried out using stochastic assignment, taking into account random factors. Stochastic assignment is more suitable for assigning cycling trips because it reflects the process of individual discrete choice. The variety of individual choices is more important to cyclists than volume-dependent journey times. When choosing a route, cyclists prefer separation from car traffic, flat longitudinal gradients and smooth surfaces without bumps (asphalt and, to a lesser extent, smooth concrete blocks) on cycle routes. The longitudinal gradient of a cycling route is the most important factor which determines the choice of a route.

The simulation analysis carried out with the use of a macroscopic model has shown, that well thought out and appropriate investments in the development of the cycling transport network are the most beneficial from the point of view of potential changes in the inhabitants' transport behaviour. The results show, that the greatest benefits for cycling in Gdynia may be achieved by filling gaps in the cycling network. The verification of the model has confirmed its usefulness in planning the cycling network, however in future studies related to modal split and route choice, some issues should be taken into account: future development of transport systems (bike-sharing and other MaaS solutions); perception of travel time; and reliability of transport network performance, including cyclists' behaviour at intersections, different user groups - e.g., by age - cycling experience and modelling of other personal characteristics, transport behaviour of pandemic travellers, the impact of weather conditions or seasonality of cycling, and impact of educational and promotional activities on cycling preferences and behaviour.

The presented spatial approach to modelling cycling behaviour opens new opportunities for planning and evidence-based decision making in the broadly understood area of cycling promotion and development, as well as for predicting and monitoring the effects of planned or implemented measures.

The methods proposed in the present Paper are worth attention and cities, which plan to develop a cycling model should apply them in their mobility planning process.

The example of Gdynia shows, that the development of an MST with a cycling model can also be proposed as good practice for other cities. This may be important for cities with emerging economies and dynamic motorisation, which will soon face the challenge of sustainable transport behaviour and needs.

Co-funded by the Erasmus+ Programme of the European Union

7) Limitations

In the decision-making process of choosing the most effective solutions, it is justified to take into account the impact of types of cycling sections on road traffic safety, energy consumption, and the environment. The model presented in the paper can be used as a basis for estimating energy consumption and exhaust emissions. The main barrier to the application of such an approach is the difficulty of obtaining data on vehicle traffic at the local level (in Polish cities). However, in future studies, these aspects will be developed using the model, so an analysis of cycling network development scenarios resulting in a change in the modal split will allow assessment of the impact of such measures on the reduction in emissions and energy consumption.

In addition, a more complex analysis using econometric techniques would be required to statistically identify the key variables that determine bicycle use. Finally, future research is needed to quantify the carbon footprint and impact of electric bicycles for certain components, such as batteries.

More research and improvement of modal split (and traffic assignment) models are required, which should take into account, for example, the impact of weather conditions or the seasonality of cycling. Other factors to be considered in further research are the impact of educational and promotional activities, and the impact of cycling's accessibility (e.g., implementation of a city bike-sharing scheme) as a mode of transport, on bicycle traffic. Another element that should be taken into account in further research is the integration of MaaS solutions into the cycling model, together with shared mobility services (including bicycle sharing, which is currently being implemented in the Tri-City agglomeration), and the possibility of changing the mode during the journey, to encourage modal shift and improve conditions for cycling.

The factor concerning traffic safety was indirectly taken into account when assessing the attractiveness of particular types of bicycle routes. However, a more detailed approach will be required in future research. To update and improve the quality of the bicycle traffic model, it is necessary to conduct regular travel surveys with appropriate sample selection in smaller transport areas. This would allow for increasing the accuracy of the estimation of the origin-destination trip matrices. Cycling speed measurements must be carried out more comprehensively, taking into account, among other things, the type of journey, the experience of cyclists, and other personal characteristics, which will help to represent the behaviour of travellers with greater precision. As the volume of cycling increases, it will also be necessary to consider the capacity of the elements of the cycling network to address cycling bottlenecks.

Co-funded by the Erasmus+ Programme of the European Union