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PROMOTION OF PEDESTRIAN URBAN MOBILITY THROUGH MICROSCOPIC TRAFFIC FLOW SIMULATION OF ENVIRONMENTAL MEASURES OF EFFECTIVENESS

Jasmina Bunevska Talevska, Marija Malenkovska Todorova
jasmina.bunevska@uklo.edu.mk, marija.malenkovska@uklo.edu.mk

Faculty of Technical Sciences
Makedonska Falanga 33, Bitola
REPUBLIC OF MACEDONIA

Key words: *urban mobility, microscopic simulation, modeling, pedestrian flow, ecological measures of effectiveness*
Abstract*: Transportation systems have become more complex and frequently congested, and as a result, a reliable description of traffic flow is a nontrivial problem. A lot of models have been proposed so far, unfortunately, none of them can be considered as an ideal or, at least, universal one. In general, traffic flow models can be grouped into four main categories depending on the level of detail: macroscopic, mesoscopic, microscopic and submicroscopic. Microscopic simulation has gained recognition as an effective way for quantifying traffic operations. Additionally, microscopic simulation models can address various types of network issues, and in more recent developments they also provide a tool for evaluating Advanced Traffic Management Systems, Travel Demand Management, Intelligent Transportation Systems and Advanced Traveler Information Systems.*
Within this paper the microscopic analysis of traffic flow, ecological parameters such as CO and NO_x Emissions through the educationally developed microscopic simulation model SFStreetSIModel, version 2.1 has been described and the microscopic simulation software introduced. Since the urban mobility planning has become the most important topic in the European Commission Sustainable urban mobility package, we hope that the results of this research will help in the procedures and actions for the development of sustainable urban mobility plan for the city of Bitola. Namely, the authors are trying to present that the analysis of environmental parameters as pedestrian traffic flow measures of effectiveness is one of the "Q" factors for sustainable urban mobility.

INTRODUCTION

In accordance with numerous relevant documents, transport is one of the principal sources of air pollution within the cities. The health effects of transport, (related air pollution), are commonly reflected through impacts on the central nervous system and respiratory system as well as the occurrence of cardiopulmonary diseases and breathing problems [1].
Therefore, there is a need to introduce solutions that reduce the risks to health and meet the requirement for mobility, which is, together with accessibility, one of the main components of the transportation system as a whole [2].

One of the solution for overcoming the mentioned issues, (proposed by [3]), is based on a three – pillar approach, Avoid – Shift – Improve. It implies," avoid – cutting out motorized travel altogether; shift means getting people to switch from high – polluting modes to low – polluting ones; and improve is about reducing the harmful environmental impacts of vehicle technology [3]." Therefore, it is obvious that the basis of such a way of solving the rising environmental concerns and problems, is sustainable urban transport, and so called sustainable urban mobility.

Advanced traffic simulation systems can support transportation planning and traffic management decision making, especially for a long-term sustainable urban development. Traffic modeling scenarios provide a big opportunity for scanning, scoping and mitigating of the traffic pollution problem which according to most authors is the biggest effort through the process of urban mobility planning.

Considering the growing field of applications and the increase of supported functionalities, a wide range of comparison studies have been completed. SMARTEST project coordinated by the University of Leeds shows in-depth comparison study of simulation tools and gives an overview on modeled objects, phenomena, and ITS functionalities [4].

In the following, we will single out several factors of importance for traffic simulations:

Main factors influencing research in simulation are:

- advanced research in traffic theory,
- advancement in computer hardware and software technology,
- development in information infrastructure and increased importance of traffic and transportation in the society.

Aspects of road traffic simulation are:

- Transport networks cover wide physical areas
- Large number of active participants or users and interaction among them
- Objectives of the participants can be individual or social (system optimum vs. user optimum)
- Presence of independent variables outside the control of the operator and the participants (the weather conditions, the number of users, etc.)
- The variables can be stochastic (inherent randomness) and time varying in nature
- Man-machine system, laws of interaction dependent on human perception

Limitations of traffic simulations are:

- Resolution: Level of detail
- Fidelity: Degree of realism
- System size: The network size to be covered
- Simulation speed: Speed of simulation compared to real time
- Resources: Computational resources, programming time

The main objective of this paper is modeling and analysis of the emissions on urban streets in order to create the model of relationship between the traffic flow parameters and air pollutant. The most important aim is directed towards obtaining the pedestrian level of service bearing in mind the role of pedestrian flow within the current green mobility approaches.

TOWARDS URBAN MOBILITY

Sustainable Urban Mobility is a planning concept applied by local authorities for strategic mobility planning. Urban Mobility Plans define a set of interrelated measures designed to satisfy the mobility needs as well as to increase people’s awareness of health issues, now and tomorrow. They are the result of an integrated planning approach and address all modes of transport in cities and the surrounding areas.

The primary focus of the National Strategy on the Sustainable Development in Macedonia [5], is placed on systematic and better management of urbanization through sustainable land use, policies and tools. The idea to analyze the need and possibilities to introduce the urban mobility concept by using simulation tools, for us as professionals, seems logical and necessary. Additionally, the use of simulation of urban streetscape and traffic flow is highly important for local public authorities, specifically those in the field of traffic and urban planning generating urban mobility strategies.

Green transport mobility as urban sustainability imperative

Green transport mobility is one of the prerequisites for sustainable, inclusive and economically effective urban development. It implies user-friendly transport systems which are based on those means of transport that have a higher capacity, use less space, and emit less pollution. On the other hand, they should be affordable and easily adaptable to citizens' needs. Therefore, walking and cycling, as well as creating frequent, high-capacity public transport are alternative solutions to personal vehicles. Their usage will limit the congestion along the streets, reduce air pollution and improve traffic safety.

How will green urban mobility help in overcoming traffic jams? Promotion and facilitation of walking, cycling and usage of transport modes nondependent on fossil fuel, as well as sharing the road by all of them, as the basic elements and values of green mobility, will: discourage the use of private motorized transport, promote new modal integration regarding transport within cities, in a word, moving towards the concept: "moving people rather than vehicles" [6]. Why worry about the impact of urban transport on air quality? Despite the fact that the emissions of certain air pollutants regarding the transport sector in the period between 1990 and 2015, are reduced, [7], it is obvious that pollutant emissions that source from transport and urban mobility, is still significant [8], (Figure 1, 2, 2.2, 2.5, page 19, 21, EEA Report No 13/2017).

The concept of green mobility offers opportunities for transition from the use of motorized modes of transport towards newly designed vehicle types, as well as the use of bikes and walking. Therefore, this concept has the potential for reducing the use of traditional automobiles in cities, number of road trips, and in that way exposure to road risks. In addition, connected mobility, (the integration of mobile information and communication technologies into vehicles, streets and cities), as the component of smart cities, has the potential for increasing road safety. It involves further development towards mobility design, which means contribution towards a safer and more accessible transport infrastructure and better protection for various road users.

Methodology of application of SFStreetSIModel, version 2.1

The third improved version of microscopic simulation model SFStreetSIModel, version 2.1 (Side Friction Street Simulation Model) simulates movement of heterogeneous traffic flow with different % participation of passenger cars, light duty vehicles, buses and pedestrians on a two lane, two way urban street, as in [9],[10].

SFStreetSIModel, version 2.1, is objective-oriented model, written in Action Script 3, implemented in Adobe Flash and Flex technology. The model is applied in the streets that form the narrower central area in Bitola, (Figure 4). The results for the level of service and exhaust emissions were obtained with a 14 hour simulation of scenarios based on the real traffic image. The model output relates to functional, safety and ecological results, and for purposes of this paper a comparison of the ecological results obtained for the same area of research in 2013 and 2018 was made.

Data collection

Since changing the way a street operates to bring about an increase in the level of sharing requires an understanding of how people currently use the space, we collected a certain amount of baseline data in form of: spot mean speed, traffic flow and classified vehicle counts, pedestrian flows, records of existing street furniture, assessment of land use and frontage activity, traffic accidents. Data accusing was made manually by filling forms ready before hand, filling Open – space forms, while traffic speed was measured with the GPS device in the vehicles (GARMIN nuvi 1390t).

Collected and analyzed data were used within the simulation model as it is shown in the dialogue window (Input), (Figure 1).

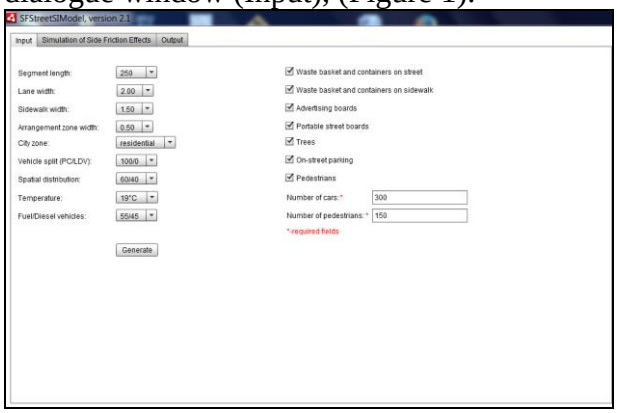

Figure 1. SFStreetSIModel,version 2.1: Location geometric and functional characteristics

SFStreetSIModel, version 2.1, output parameters showed on Figure 2, 3 enable analysis of effectiveness, safety and environmental conditions at the studied locations.

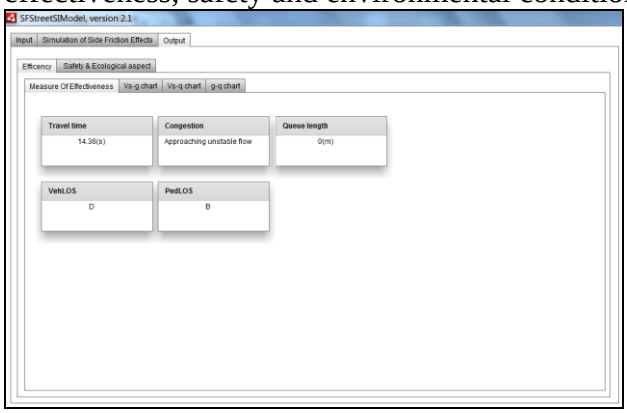

Figure 2. An example of simulated pedestrian level of service

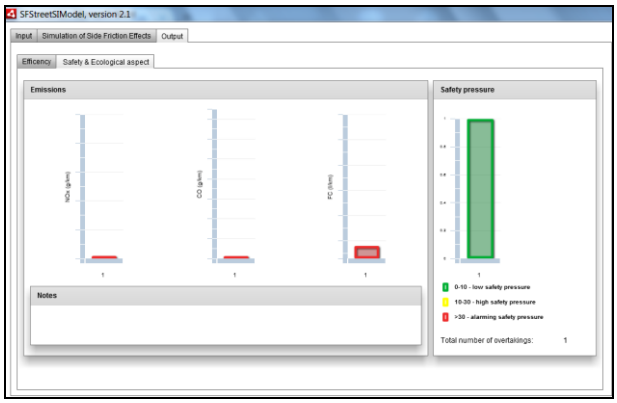

Figure 3. An example of simulated Safety and Ecological Measures

Micro simulation results comparison

Results are obtained for the same area of research and for data collected from the field in May 2013, [11],[12] and May 2018. In the process of method formulation some aspects of flow circulation in comparison to other (geometric elements, vehicular flow, etc), were considered. Since often recorded results are not comparable among themselves unless all the analytical methods used in the same case study are applied, here, the results obtained by the study were analyzed in terms of pedestrian level of service and emission levels, (Table1).

Table 1: Comparison of simulation features, SFStreetSIModel, version 2.1, 2013 v.s. 2018

	PedLOS		CO Emissions (g/km)		NO_x Emission (g/km)	
Street (Name)	**2013**	**2018**	**2013**	**2018**	**2013**	**2018**
Filip II Makedonski-Bataljon Stiv Naumov	**C**	**D**	**0.21**	**0.51**	**0.13**	**0.28**
Bataljon Stiv Naumov - Prilepska	**D**	**E**	**0.16**	**0.51**	**0.07**	**0.12**
15 Maj – Prilepska – Cvetan Dimov	**C**	**B**	**0.11**	**0.66**	**0.09**	**0.16**
4ti Noemvri – Dimitar Ilievski Murato	**C/D**	**D**	**0.18**	**0.24**	**0.14**	**0.26**
Dimitar Ilievski Murato - Nikola Tesla	**D**	**E**	**0.19**	**0.33**	**0.1**	**0.22**
Stolarska – Dobrivoje Radosavljevik	**C**	**D**	**0.20**	**0.76**	**0.1**	**0.15**
Zone total		**/**	**1.05**	**3.01**	**0.63**	**1.19**

From the data in Table 1, it can be said that the emissions of CO and NOx have increased in the studied zone by 28.4% and 18.9%, respectively, as well as pedestrian level of service decreased in range from C-medium to E-low. That means that new measures should be proposed and implemented.

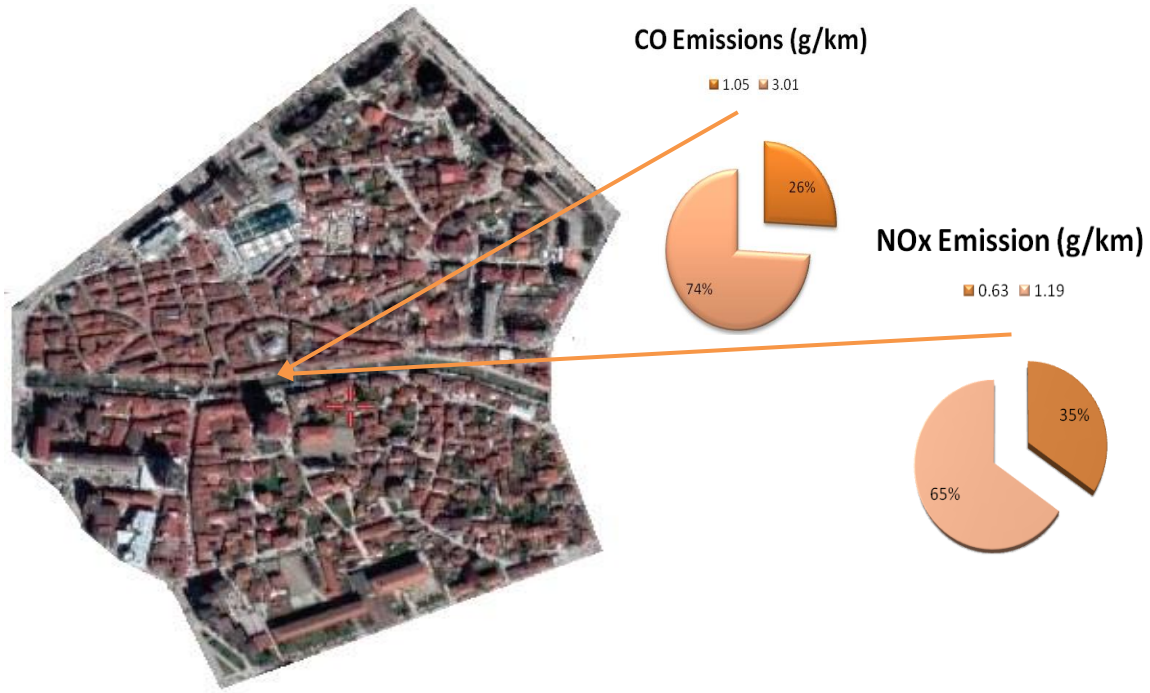

Figure 1. Area under study - Narrow central zone of Bitola
Source: (adopted by authors)

CONCLUSIONS AND RECOMMENDATIONS

The characteristics of lifestyle in the cities of today create a lot of requirements for high quality levels of mobility. When it comes to air quality, reducing pollutant emissions at source from transport and urban mobility is a very important topic in the latest relevant documents worldwide.

Focusing on sustainable urban mobility challenges, such as using of alternative – fuelled vehicles, promotion of low - impact means of transport, introduction of low emissions zones, greener logistics, are some of the ways of keeping air pollution below limit values. Namely, an integrated and coordinated approach is one of the recommendations made towards ensuring sustainable green mobility in cities.

By modeling and simulating of the overall street geometry, streetscape and traffic characteristics as well, this model as a whole provides measure of effectiveness in term of safety, effectiveness and environment. For the purposes of this research, certain estimations, for instance, emission levels (NOx, CO) and pedestrian level of service are considered as environmental measures of the effectiveness of traffic flow. A selection of these indicators is motivated by two reasons, first because CO and NOx emissions are emissions which are regulated by European Legislation about vehicle polluted emissions [13], and second because final energy saving and CO_2 emissions are common indicators used by [14] to assess the environmental performance of a city.

With this paper we present the impact of simulation modeling on preparing and upgrading measures for urban mobility plans and the approach which will help and supports the decision making process from an environmental point of view. Moreover, simulation model outputs are also helpful to disseminate the advantages of urban mobility plans among society.

In a period of time in which local authorities are working to improve the cities' quality of life, the presented methodology demonstrates how it can be reliably quantified when a new transport system measure is implemented, such as: cleaner fuels, enforcing fuel standards, alternative fuels measurements, hybrid's and electric propulsion, improving fuel efficiency through vehicle technology, increasing fuel efficiency through vehicle operation, discouraging the use of motorized transport, local environmental management by pedestrianization of city centers and policy for land use planning in ways that minimize travel requirements, and particularly minimize private car movements for a given level of activity, etc.

For the purpose of contributing this research aspect, we plan to continue with the analysis of particulate emissions as a function of vehicle speed.

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НАСЪРЧАВАНЕ НА ГРАДСКАТА МОБИЛНОСТ ЧРЕЗ СИМУЛАЦИЯ НА ТРАФИК В МИКРОСРЕДА ПРИ ЕФЕКТИВНО СПАЗВАНЕ НА УСЛОВИЯТА ЗА ЕКОЛОГИЧНОСТ

Ясмина Буневска Талевска, Мария Маленковска Тодорова.
jasmina.bunevska@uklo.edu.mk, marija.malenkovska@uklo.edu.mk

Факултет по технически науки
Ул. „Македонска фаланга“ 33, Битоля
МАКЕДОНИЯ

Ключови думи: *градска мобилност, симулация в микро среда, моделиране, пътнико поток, ефективни екологични мерки.*

Резюме: *Транспортните системи представляват сложни системи, които често се задръстват от движението на превозните средства, в резултат на което надеждното изследване на трафика е важен въпрос. Към момента са предлагани редица модели за изследване на трафика, но за сега никой от тях не е възприет като идеален или универсален. По принцип моделите за изследване на трафика могат да бъдат групирани в четири категории, които зависят от нивото на детайлизиране: изследване в макросреда, в мезосреда, в микро среда и в суб-микро среда. Изследванията на трафика в микросреда се възприемат като ефективен начин за количествено измерване на трафика. Още повече, моделите за симулиране на трафик в микросреда позволяват да се изследват различни транспортни мрежи, като същевременно представляват инструмент за оценяване на усъвършенствани системи за управление на трафика, системи за управление на търсенето на превози от населението, интелигентни транспортни системи и системи за осигуряване на информация за пътниците.*

Настоящата разработка има за цел да представи анализи в микро среда на трафика в съответствие с екологичните норми за емисии на CO и NO_x, като се използва симулационния модел SFStreetSIModel, версия 2.1. Тъй като планирането на градската мобилност е една от най-важните теми в пакета на Европейската Комисия за устойчива градска мобилност, то авторите на настоящата публикация считат, че резултатите от изследването могат да се приложат за постигането на устойчива градска мобилност в град Битоля. Още повече, авторите правят опит да докажат, че анализа на параметрите за екологичност по отношение на трафика са едни от качествените показатели за постигане на устойчива градска мобилност.