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EVALUATION OF ROAD SAFETY PERFORMANCES IN URBAN AREAS

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Key words: *road safety, safety performance function, urban transport network modelling*

Abstract: *Urban road safety directly affects whole city area and all its inhabitants. Therefore traffic safety constitutes a constant objective in development and management of transport regulation. The state of road accident in Romania presented in statistical reports at national and European level underlines the needs of research on identifying the appropriate measures for road safety enhancement. Our proposed goal is to develop a set of functions for evaluation of the road safety for different traffic intensity pattern and for estimating various traffic management schemes.*

In the first part of the paper we present the state of road accident recorded in Bucharest and we classify the main causes of the urban road accident. In the second part of the paper we describe a macroscopic model developed for estimating of safety performance based on physical characteristics of network, traffic intensity and recorded data on road accidents. The resulted macroscopic digital network model has to be base for assigning the traffic flows and further, inputs of the model for estimating the traffic safety performances. The main objective of the presented model is to identify practical solutions that lead to traffic safety enhancement.

INTRODUCTION

Because road safety represents an important social issue, the European Commission pointed out in the White Paper from 2011 the necessity of road safety assessment in order to identify and manage the section with high risk of accidents and stated the aim of halving road casualties by 2020. From year 2000 until 2009 In period 2000 - 2009 at European level the number of road accidents decreases over 38% and number of urban road accidents decreases over 32% (CARE, 2011). This status determined the restating the aim of halving the road victims in the White Paper from 2011.

Unfortunately the road accidents statistics from Romania have not adjoined the European decreasing tendency (Fig. 1). If the number of road fatalities is divided to population of each country, then 81 persons from one million of Romanian inhabitants are fatal victims of urban road accident, much more than the average value of 26 fatalities per million of inhabitants at European level. In 2009 over 68% of road accident fatalities from Romania were recorded in urban areas (CARE, 2011).

In Bucharest, a big city where about 10% population of Romania is concentrated, the number of road accident remain still significant even if a decrease comparative to 2008 is recorded (Fig. 2). Figure 3 shows the weight of main causes of road accidents registered in 2009.

The situation of road accidents in urban areas from Romania presented in the mentioned charts expresses the necessity of research on identifying of appropriate measures which lead to improvement of road safety. In the next section we propose a conceptual model developed for Bucharest Metropolitan area for estimating the urban traffic safety at the planning stage, having a predominant predictive character. That means that for a transport network structure and a traffic flows pattern the areas with high risk of traffic accident are selected, classified according by physical characteristic but also by traffic volume and finally possible solution for enhancement of the safety performance are identified.

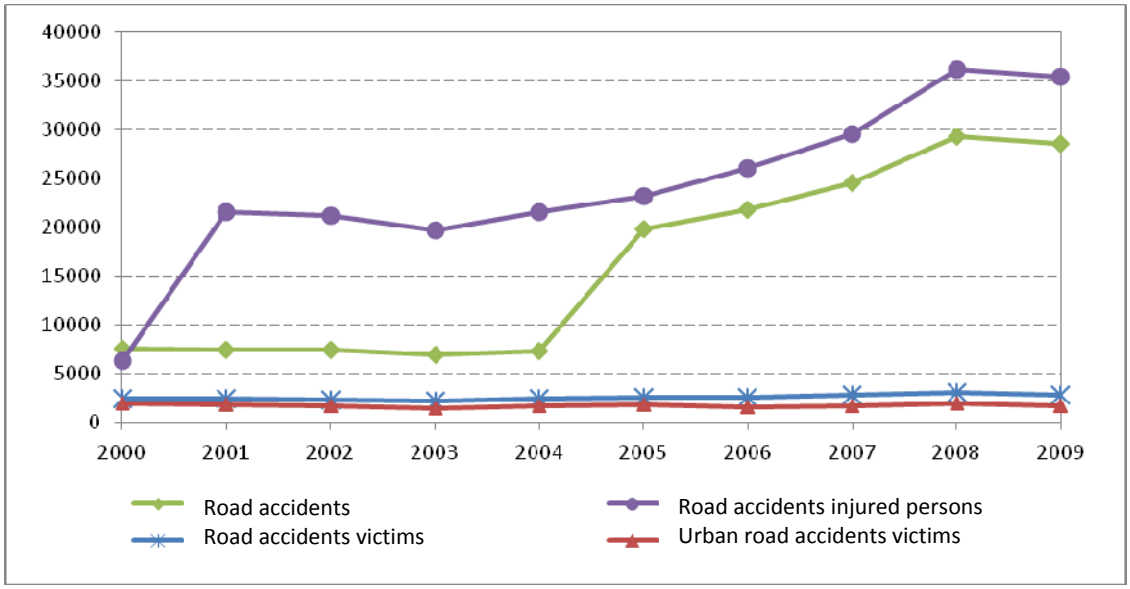

Fig. 1. Road accidents and fatalities registered in Romania, period 2000 – 2009 *(CARE, 2011)*

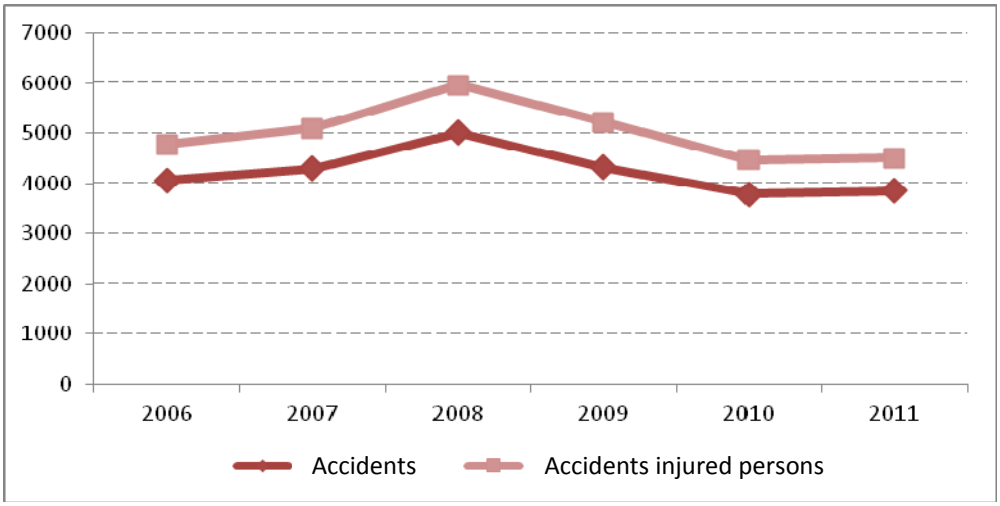

Fig. 2. Road accidents in Bucharest in period 2006 – 2011

MODEL FOR SAFETY PERFORMANCE ESTIMATION

In order to obtain accurate accident estimation it is necessary to develop a complex model, including besides a network model with physical, geometrical and technical characteristics, also a macroscopic digital network appropriate for traffic macro simulation. In this section we present the structure of the safety performance estimation model (Fig. 4).

In mathematical and simulation modelling the urban road network, moreover as any transport infrastructure network, is associated with graphs defined by nodes and edges. The representations of urban road infrastructure differ function on modelling objectives. The significant differences consist in level of particularization of physical network. Even the same network representation could have different functional characteristics in terms of traffic flows assignment. In the model for estimating of traffic safety performances the digital urban road representation requires the description of relations on:

- network geometry, defined by nodes coordinates, length and shape of edges;
- classification and codification of edges function on their importance evaluated by road category (avenues, major and arterial streets, collector streets etc.), capacity (number of lanes, lane width), transit usage (section with both road lanes and tram and light-train tracks, bus dedicated lanes etc.), speed and flow intensity, congestion rate;
- curves speed-traffic flow (which have an essential role in modelling);
- classification and codification of junctions which are network component with frequent traffic problems. The propagation of the traffic problem occurred in one intersection determines the capacity of the connected roads and even the capacity of the extended adjacent network zone. If the junction geometry is detailed represented then for every allowed turn the corresponding junction time can be correct established.

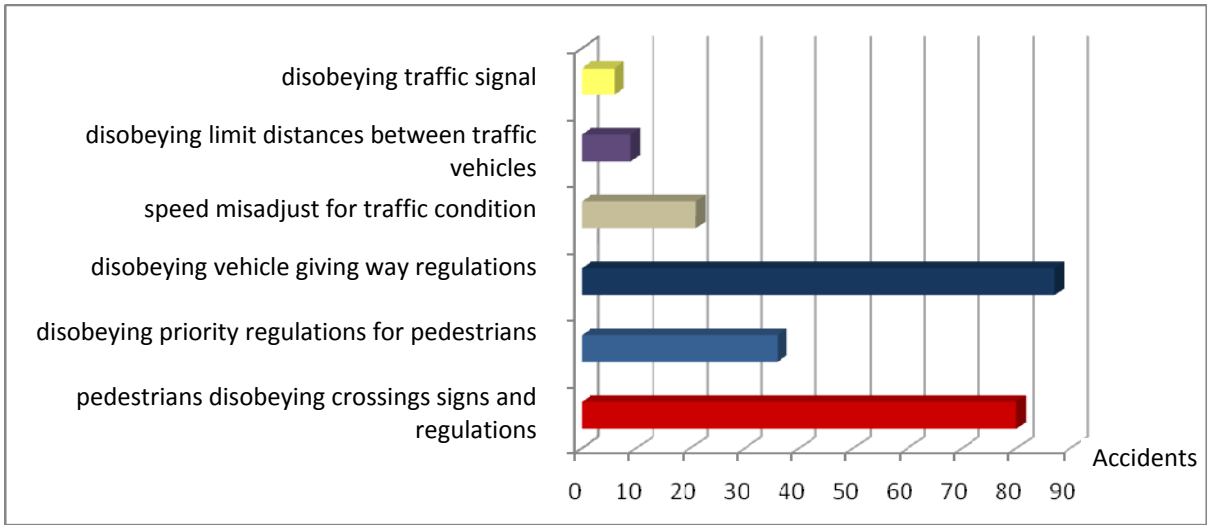

Fig. 3. Categories of road accidents recorded in Bucharest in 2011

Starting from the digitized urban physical network the appropriate macroscopic digital network is modelled. The macroscopic digital network is defined by nodes *(*which may correspond to physical intersection or point where local traffic is assigned), centroid zone connectors and links (which may correspond to section of the major and arterial roads). The coding and digitization of the urban transport network features are important steps because the result will characterize the topological assignment pattern of the traffic flows. Selecting only the arterial and major street for defining the links of the digital network can lead to an overestimating of the number of accident on links. An adjustment is necessary and in some

cases microscopic simulations have to be applied in order to identify the appropriate coding solution or potential issues regarding the macroscopic traffic flows allocation.

It was demonstrated that traffic flows explain more than 50% of accident occurrence, particularly for urban networks (Kulmala, 1995). In order to obtain accurate accident estimation there is necessary to develop a complex model, including besides a network model with technical characteristics, also a traffic flows model. Then the initial obtained macroscopic digital network model has to be base for assigning the flows and further, the resulted traffic flows pattern will constitutes inputs of the model for estimating the traffic safety performances (Fig. 4).

Safety performance functions will be defined to estimate the number of accidents on road infrastructure features, taking into account the physical network characteristics, the traffic flows intensity and accidents statistics. Base on analysis of the network features with low safety performances the possible solution to improve the safety performance will be identified.

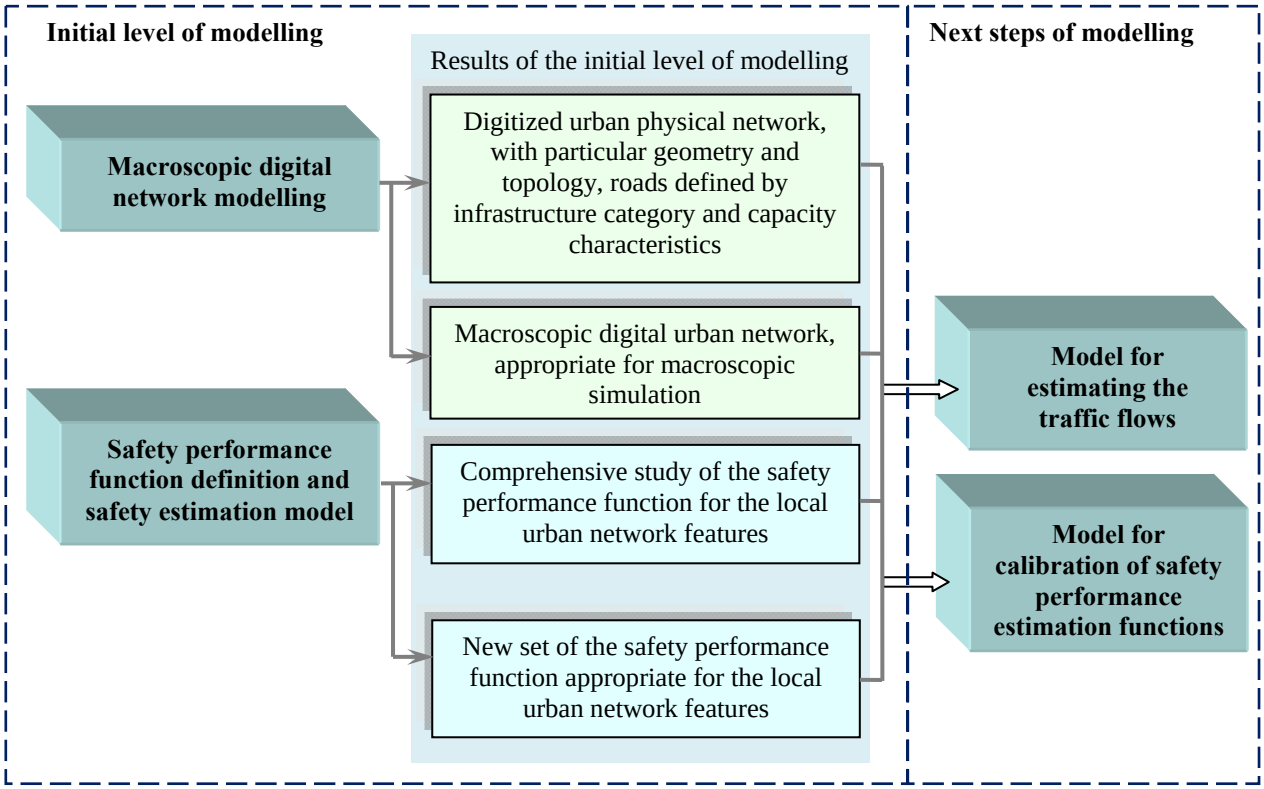

Fig. 4. Main steps of development of safety performance estimation model

However defining appropriate safety performance function is a complex issue. There are series of safety performance functions defined for highways (Qin and Ivan, 2005; Lord and Bonneson, 2006), for rural areas crossed by highways (Harwood et al. 2000) and for urban network (Elvik, 2009; Lord and Persaud, 2000). In literature we can distinguish three main categories of safety performance functions for the urban transport infrastructure (Table 1):

Table 1

Class of safety performance function	Characteristics used to group the safety performance functions
I. Functions developed for estimating the accidents number in major intersections, where flows from major and arterial streets interact	▪ Signalized four-legged ▪ Signalized three-legged ▪ Un-signalized four-legged ▪ Un-signalized three-legged
II. Functions for estimating the accident number in minor intersections, where flows from major and arterial streets and flows from collector and residential interact	▪ Signalized four-legged ▪ Signalized three-legged ▪ Un-signalized four-legged ▪ Un-signalized three-legged
III. Functions applied on the section between intersections (mid-block)	▪ Two lane roads ▪ Four lane ▪ Six lane roads

All the mentioned functions are defined for infrastructure dedicated only for road vehicles. No features with both road and tram infrastructure have been considered. Consequently for our research an additional difficulty is given by the characteristics of ground urban transport infrastructure. In Bucharest there are many sections of roads for tram and cars with included rail infrastructure and adjacent road infrastructure or section of roads with mixed use for tram and cars (with rail track included in road infrastructure). Thus supplementary categories of functions have to be defined.

Each class includes a set of functions defined accordingly with the characteristics of the infrastructure elements. The traffic flows assigned on the digital network determine the category of the adequate safety performance function. Accident statistic databases are necessary to validation and calibration of safety estimation procedures. Figure 5 shows an example of map of recorded accidents used for analysing and identifying the characteristics of zones with high risk of accidents.

Supplementary experimental research will be performed to emphasise the safety performance sensitivity. The model results will be useful tools for estimating of urban traffic safety, allowing the analyse of different traffic flows patterns and the identifying of appropriate solutions for improving traffic safety performance at the stage of new facilities design.

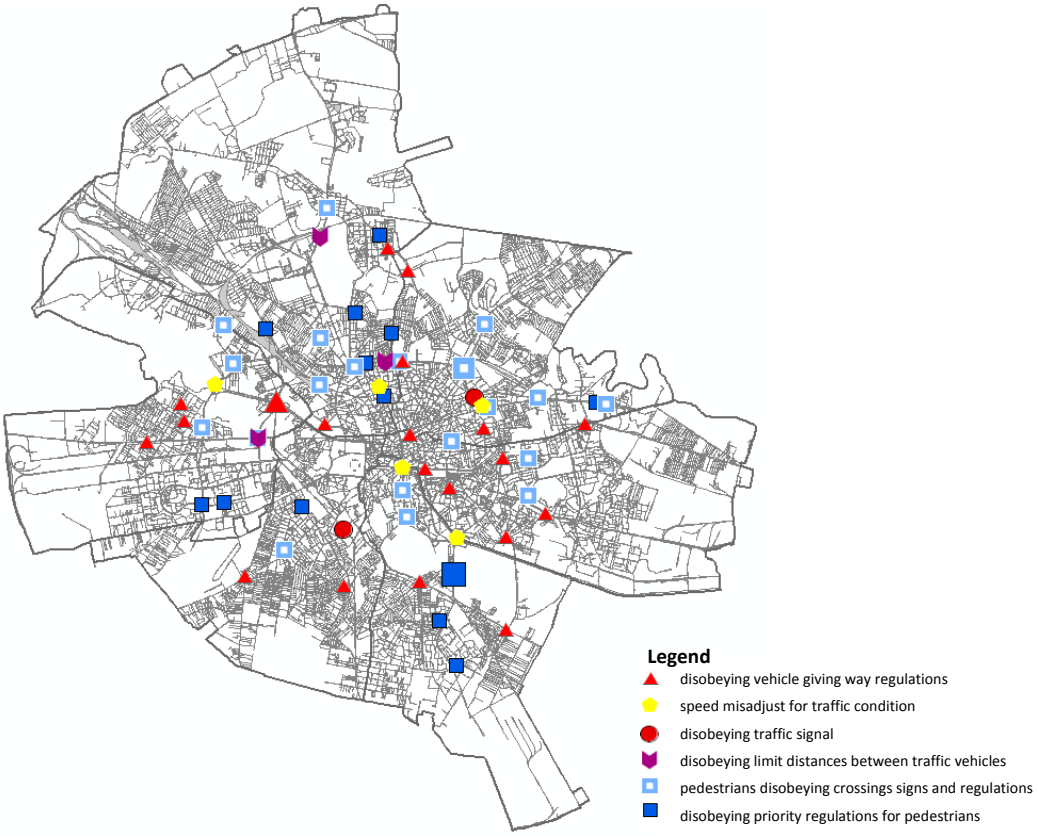

Fig. 5. Map of road accidents recorded in Bucharest in 2011

CONCLUSION

Generally, the most urban transport and traffic studies focus on travel time, congestion delays, environmental impact, without taking into account the safety estimation. Although traffic safety is considered an important social and environmental issue, the traffic safety performances quantification are made after designing, construction and using of transport infrastructure. Black spots are identified only after traffic and accidents data gathering and analysis. After that, correcting measures are applied. Throughout the presented model we intend to develop geo-databases structures, methods and models for estimating the safety performance and number of accidents at the planning and designing step. Simulating tools will be developed in order to analyse different scenarios and traffic flows pattern and to identify appropriate solutions for safety performance improvement.

For obtaining this goal further research on several complex modelling issues are required:

- defining of safety performance functions, appropriate for inhomogeneous and complex features of Bucharest road network. In literature there are no definition of safety performance functions which including transit flows vehicles. Because in Bucharest road network and ground transit network are located in the same urban area, multiple connexions exist between the two networks which has to be underlined by studies on urban road safety studies;
- calibrating of safety performance function parameters taking into account the fluctuant Bucharest traffic flows pattern and the impact of trams and light-train transit services on road safety performances.

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REFERENCES:

[1] Elvik R. "Developing accident modification functions: exploratory study", Annual Meeting of the Transportation Research Board. Proc., 88th, Washington, 2009

[2] European Commission - Directorate General Energy and Transport, "CARE (EU road accidents database)", http://ec.europa.eu/transport/road_safety/specialist/statistics/index_en.htm

[3] European Transport Safety Council (ETSC), "A Methodological Approach to National Road Safety Policies", Brussels, 2006

[4] European Transport Safety Council (ETSC), "Transport Safety Performance Indicators", Brussels, 2001;

[5] Hakkert A.S., Gitelman V., Vis M.A. (Eds.) "Road Safety Performance Indicators: Theory", Deliverable D3.6 of the EU FP6 Project SafetyNet, 2007

[6] Harwood D.W., Council F.M., Hauer E., Hughes W.E., Vogt A. „Prediction of expected safety performance on rural two-lane highways", Report No. FHWA-RD-99-207, Federal Highway Administration, 2000

[7] Kulmala R. "Safety at Rural Three- and Four-Arm Junctions: Development and Applications of Accident Prediction Models", VTT Publications 233, Technical Research Centre of Finland, Espoo, 1995

[8] Lord D., Bonneson J.A. "Role and Application of Accident Modification Factors (AMFs) within the Highway Design Process", Transportation Research Record 1961, 2006, pp. 65-73

[9] Lord D., Persaud B.N. „Accident Prediction Models with and without Trend: Application of the Generalized Estimating Equation Procedure" Transportation Research Record 1717, Transportation Research Board of the National Academies, Washington, D.C., 2000

[10] Qin X., Ivan J.N., Ravishanker N, Junfeng Liu J.4 „Hierarchical Bayesian Estimation of Safety Performance Functions for Two-Lane Highways Using Markov Chain Monte Carlo Modeling" Journal of Transportation Engineering 5, 2005.

ОЦЕНКА НА ХАРАКТЕРИСТИКИТЕ НА БЕЗОПАСНОСТТА НА ДВИЖЕНИЕ В ГРАДСКА СРЕДА

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Ключови думи: *безопасност на движението, функция на ефективност на безопасността, моделиране на градска транспортна мрежа*

Резюме: *Безопасността на движението в града влияе пряко на цялото населено място и всички негови жители. Следователно безопасността на движението е ключов фактор в разработването и управлението на транспортната мрежа. Данните за пътнотранспортните произшествия в Румъния, представени в статистическите отчети на национално и европейско равнище, подчертават нуждата за изследвания с цел идентифицирането на подходящи мерки за подобряването на безопасността на движението. Нашата цел е да разработим набор от функции за оценка на безопасността на движението, използвайки различни модели на интензивност на трафика, а също така и за оценка на различни схеми за управление на трафика.*

В първата част на статията представяме регистрираните в Букурещ пътнотранспортни произшествия и класифицираме основните причини за пътните инциденти в градска среда. Във втората част на статията описваме макроскопичен модел, разработен за оценка на ефективността на безопасността. Този модел е базиран на физическите характеристики на транспортната мрежа, интензивността на трафика и данните от пътнотранспортните произшествия. Този дигитален модел ще бъде основа за определяне на потоците на движение. Данните от този модел могат да служат за оценка на характеристиките на безопасността на движение. Основната цел на представения модел е да се идентифицират практически решения, които водят до повишаване на безопасността на движение.