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EFFECTS OF IMPROVED MANAGEMENT OF TRAFFIC FLOWS ON SUSTAINABLE ROAD SAFETY

Summary. Knowledge of the improved management of traffic flows and its effect on road safety is an important component in the process of sustainable road network development. Having in mind the fact that so many road traffic casualties occur, a key priority in European Transport Policy is making Europe's highways as safe as possible. The mentioned objective is attained by means of sustainable safety. The various traffic models, developed on the base of the characteristics of different road users and their often conflicting requirements, have a vital role in the mentioned process. This paper investigates the applicability of existing traffic flow models in the efforts to achieve sustainable safe road traffic. This characteristic is limited, because these models are based, primarily, on traffic conditions of cars or motorized vehicles of similar characteristics. The aim of the paper is to contribute to sustainable safe road traffic, emphasizing the need to develop the models which must be taken into account of the users of different transport modes having conflicting requirements.

ВЛИЯНИЕ УЛУЧШЕНИЯ УПРАВЛЕНИЯ ТРАНСПОРТНЫМИ ПОТОКАМИ НА УСТОЙЧИВУЮ БЕЗОПАСНОСТЬ ДОРОЖНОГО ДВИЖЕНИЯ

Аннотация. Знание в области усовершенствования управления транспортными потоками и его влияния на дорожную безопасность является важным компонентом в процессе устойчивого развития дорожной сети. Имея в виду тот факт, что на дорожном транспорте имеет место большое количество жертв, ключевым приоритетом европейской транспортной политики является сделать европейские шоссе столь безопасными насколько это возможно. Упомянутая цель может быть достигнута посредством устойчивой безопасности. У различных транспортных моделей, разработанных на основе особенностей различных дорожных пользователей и их часто противоречивых требований, есть насущная роль в упомянутом процессе. Эта статья исследует применимость существующих моделей транспортных потоков с целью достигнуть устойчиво безопасного дорожного транспорта. Эта характеристика ограничена, поскольку эти модели базируются, прежде всего, на транспортных условиях автомобилей или моторизованных транспортных средств с подобными характеристиками. Цель статьи состоит в том, чтобы поспособствовать устойчивому безопасному дорожному транспорту, подчеркивая необходимость разработки моделей, которые должны быть приняты во внимание пользователей различных транспортных моделей имеющих противоречивые требования.

1. INTRODUCTION

Thanks to its basic characteristics, opportunity for the personal mobility and freedom of movement, road transport is the most important mode of transport in the majority of countries in the world.

On the other side, in world scale, it is the cause for loss of more than 1,2 million lives and about 50 million injuries annually. [1] The situation is similar on the roads in Europe. According to [2] 40 000 road users are killed, and the annual number of injuries is many folds bigger.

The same is true for European countries in transition. For example, the number of crashes in the Republic of Macedonia, in 2006 was about 17% bigger than in 2005, and in 2005, even 40% bigger than in 2004.[3]

In order to improve such situation, the EU Commission undertook plenty of measures. The achievement of a higher safety level on European roads, is of high priority on the agenda of the European Transport Policy. For example, improving of road safety is one of the principal measures proposed in the White paper of the European Transport Policy for 2010 [2]. In accordance with the Mid-term review of the European Commission's 2001 Transport White Paper,[4] so called sustainable mobility in Europe must be followed by safety and security of all users and providers of transport services. These achievements are through the process of undertaking the variety of measures, such as: new traffic legislation, the expansion of the freeway road network, vehicle safety systems, and also the improved management of traffic flows on road network.

2. THE PRINCIPLES OF SUSTAINABLE ROAD NETWORK DEVELOPMENT

There are many definitions for sustainability. One of the most useable is: "Sustainable development is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [5]. Perhaps, the appropriate definition for the road network development field, according to [6], is that sustainable development means, "Development that is likely to achieve lasting satisfaction of human needs and improvement of the quality of human life", or simply said, the sustainable development of road network must be focused on people needs. This user-oriented system approach can be achieved by so called guiding principles which ought to be used in the process of the road network development. The most important principles, (mostly of them are the objectives of the transport policy at all), resulted from the field of traffic and transport engineering, psychology and biomechanics. They are:

- Mobility,
- Environmental protection,
- Reliability,
- Safety,
- Security,
- Co-modality,

Developing an efficient, well integrated and complete road network is the base for the increasing **mobility** of the road transport users. The enlargement of the European Union, has emphasized the need of **sustainable mobility**, in other words, mobility is developed on the base of various road users, their needs and their rights. Lately, so called **intelligent mobility**, (the result of the usage of intelligent road transport infrastructure), is actual.

Road transport is a transport mode with big pressure on the environment. So, the **environmental concern**, (through the environmental impact assessment from transport, updating the international legislative in the field of transport and environment, policy issues, measures for reducing negative impacts on the environment), is an important topic in the process of road network management.

Reliability is the principle which ought to be followed in order to attain consistent quality of the road transport services. Nowadays, the major concern ought to be given to passenger rights, first of all, those with reduced mobility.

Having in mind the characteristic of this transport mode, high level of risk for traffic injuries, a **radically new approach to managing road safety**, is needed. It is directed on several elements of road transport system, such as: road infrastructure and the improved management of traffic flows on it; vehicle construction and technology, in order to satisfy various users needs, and on permanent education, information and control, (where it is necessary), people as the transport participants.

Nowadays, transport sector **security**, as well as the concern about the **road users protection**, has become more significant. That means, proposes the rules and takes the measures to enhance the security, first of all in air and maritime transport, and then extended them to the other transport modes, such as road transport sector. The road transport infrastructure is a target of specific protection measures which ought to be undertaken.

Co-modality promotes a need for efficient involvement of various transport modes in the process of realizing transport service. That means, their optimal and sustainable usage, everywhere is needed. Road transport is mostly suitable for transport services in which mobility and flexibility is needed. In the process of multimodal services, it is used as a link to other transport modes, usually at the beginning and at the end of trips.

2.1. Sustainable safety, as a crucial element of road network development process

It is clear that safety is one of the most important principles in the process of road network development. It is the basic prerequisite for accomplishment of the others. This statement is based on the fact, that without safety, neither of them can be fulfilled as a whole.

Road transport is characterized with low level of traffic safety, in comparison with the other transport modes. On the other hand, most passengers and goods flows go by roads. In 2004, this transport participated with 73,6% of passenger transport, as well as, 44,4% of all goods transport in the EU – 25.[7]

Having in mind this transport mode is the essential part of each individual life, road safety is the prime concern of the European Transport Policy.

In order to improve this characteristic, an **organized, sustainable approach** is needed. That means, concentrated action of all of the participants in the process of realizing the transport service, such as: governments at all levels, those who are professionally engaged in transport and traffic engineering and road users themselves.

As a result of the analysis of numerous road accidents, it is found that human error is the main reason for 90% of them. So, in well organized and integrated road network development approach, people are in the centre of the undertaken measures. Safety strategy with efficiently connections between the elements of traffic and transport system is called **sustainable safety strategy**. It means, the approach in which, man, vehicle and infrastructure are connected in the way which will give, as a result, a high level of road safety.

These are some of the **most important principles of sustainable road safety**:

- Prevention is better than cure,
- Proactive and preventive approach has the central role in the sustainable safe traffic system.
- All of the transport system elements, people, vehicles and road infrastructure are geared to one another.
- Human capacities are the weakest link in the traffic and transport safety chain, (because of the human characteristics), so, they are incorporated in sustainable safety as a reference against which other system elements are gauged.
- As a consequence of above mentioned, road safety depends very little on individual road users decisions.

Briefly, we can say that **the basic and most important element of the sustainable road safety is well informed and educated road user with his personal features**. Road infrastructure and vehicles,

ought to be adapted to the users demands, in order to simplify driving, and protection first of all vulnerable, and the other people, participants in traffic and transport.

The contribution of the road infrastructure in sustainable road safety, is the result of:

- Proper categorization of the roads, respecting the functional principle:(roads with a through, direct and accessible function),
- Road design in accordance with its function,
- Road legislation which is based on the regulatory requirements,
- Road usage which is the result of the road user behaviour.

So, we can conclude that safety is an essential element of particular phases of road development process, beginning with planning, design, construction and maintenance of roads.

The accomplishment of mentioned properties of road network, is a basic element for efficient management of traffic flows.

On the base of the above mentioned, it can be concluded that road infrastructure, that means, classification of the facilities, design parameters, and in connection with it, the characteristics of vehicles' movement, are the basic factors which influence on safety.

3. TRAFFIC CHARACTERISTICS AND SAFETY

Traffic flow can be described as a simultaneous movement of vehicles on a road. This process is characterized with accidental elements of vehicles and drivers characteristics and their mutual impact.

Traffic flow models are used as a tool for understanding the process of vehicles' movement, which contributes significantly to analysing and solving various problems in traffic and transport engineering.

As a result different approaches have been applied to describe the properties of traffic flows, a wide variety of traffic models exist.

Based on the level of detail, there are three types of traffic models: **microscopic, mesoscopic and macroscopic**.

Microscopic models are models in which every single vehicle movement is described, including the interaction between vehicles.

Medium level of detail in the process of describing traffic flows are the basic characteristic of **mesoscopic models**.

Macroscopic models are used in order to describe movement of all vehicles on an analyzed road section.

Traffic flow rate or volume, speed and density, are basic variables which are used in the process of analyzing of the legalities of traffic movement on a road.

Volume and traffic flow rate are quantitative measures of traffic passing a point or section on a lane or road.

Speed presents the distance which is covered by the vehicle per unit of time.

Density is the number of vehicles on a given length of a road.

The basic relationship between speed, density and flow rate in theoretical ideal conditions, in uninterrupted traffic stream, is stated in equation 1.

Theoretical ideal technical-exploitative conditions of traffic lane and traffic flows are, a little bit different, according to various authors. In Macedonian professional literature, ideal technical-exploitative conditions are: Traffic flow consists of passenger cars only, lane width bigger than 3,5 m, lateral clearance bigger than 1,75 m, level terrain and excellent condition of carriageway.

$$q = V \cdot g \quad (\text{veh/h/ln}) \quad (1)$$

where: q – flow rate (veh/h/ln); V – speed (km/h); g – density (veh/km/ln)

Graphic presentation of the basic relationship is given in Figure 1 [8].

The interaction of the basic parameters of traffic flow, in real, but nearly ideal road and traffic conditions, are presented in Figure 2. The analysis of such a kind of conditions, means next step towards real conditions, in order to define the adequate tool for researching and solving various situations which occur on road network. But, they are still based on homogeneous structure of traffic flows, first of all, on motorized vehicles.

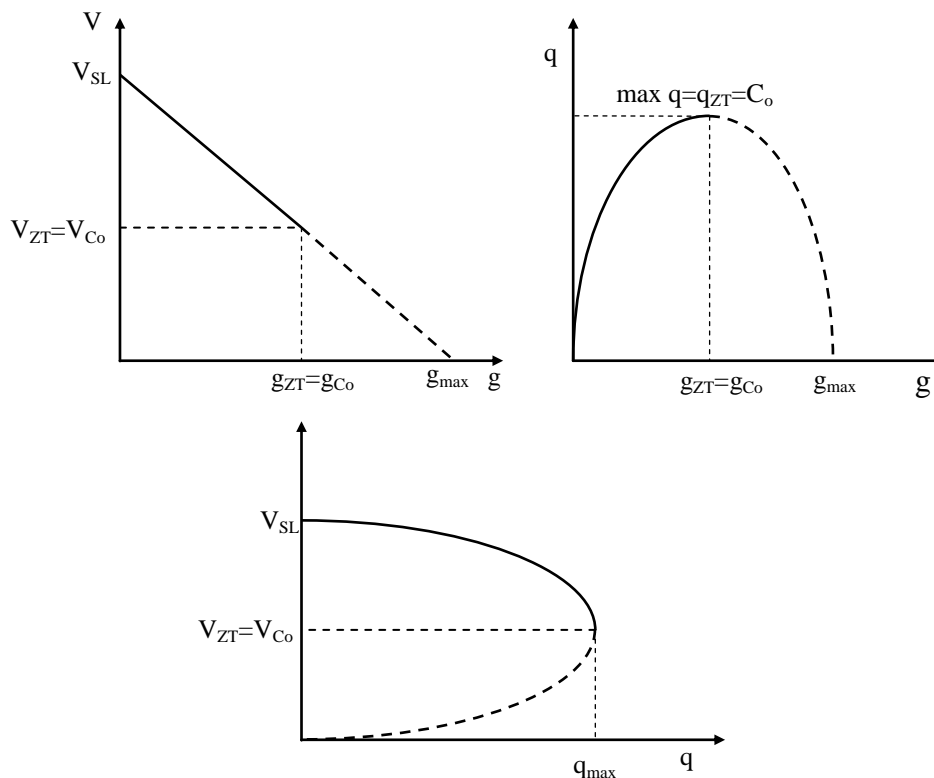


Fig. 1. Graphic presentation of the generalized relationship among the speed, density and flow rate, in theoretical ideal conditions

Рис. 1. Графическое представление обобщенных соотношений среди скорости, плотности и расхода в теоретических идеальных условиях

3.1. Traffic flow models towards sustainable traffic safety

Lack of traffic safety on our roads, is becoming an even more pressing problem in countries all over the world. In plenty of ways to solve this, is knowledge of the characteristics of traffic flow models and their impact on traffic safety.

In the frame of investigations, it was found that traffic variables, specially traffic volume and speed, have great impact on accidents rate.

The form of the relationship between accidents and traffic flow is often assumed to be a linear, but really, it is U-shaped. It means, higher crash rates are observed when traffic volume is low.

Type of accidents depends of mentioned traffic flow parameter. So, the percentage of multiple-vehicle accidents decreases, but the percentage of single-vehicle crashes increases as the traffic volume decreases.

The results of some investigations evidence that prevailing traffic flow conditions, (different traffic flow regimes- Figure 2), also affect accidents characteristics [9].

Speed, actually the speed variance, also affects safety. If speed deviation increases, for all flow rates, the crash rate also increases, especially for two lane highways.

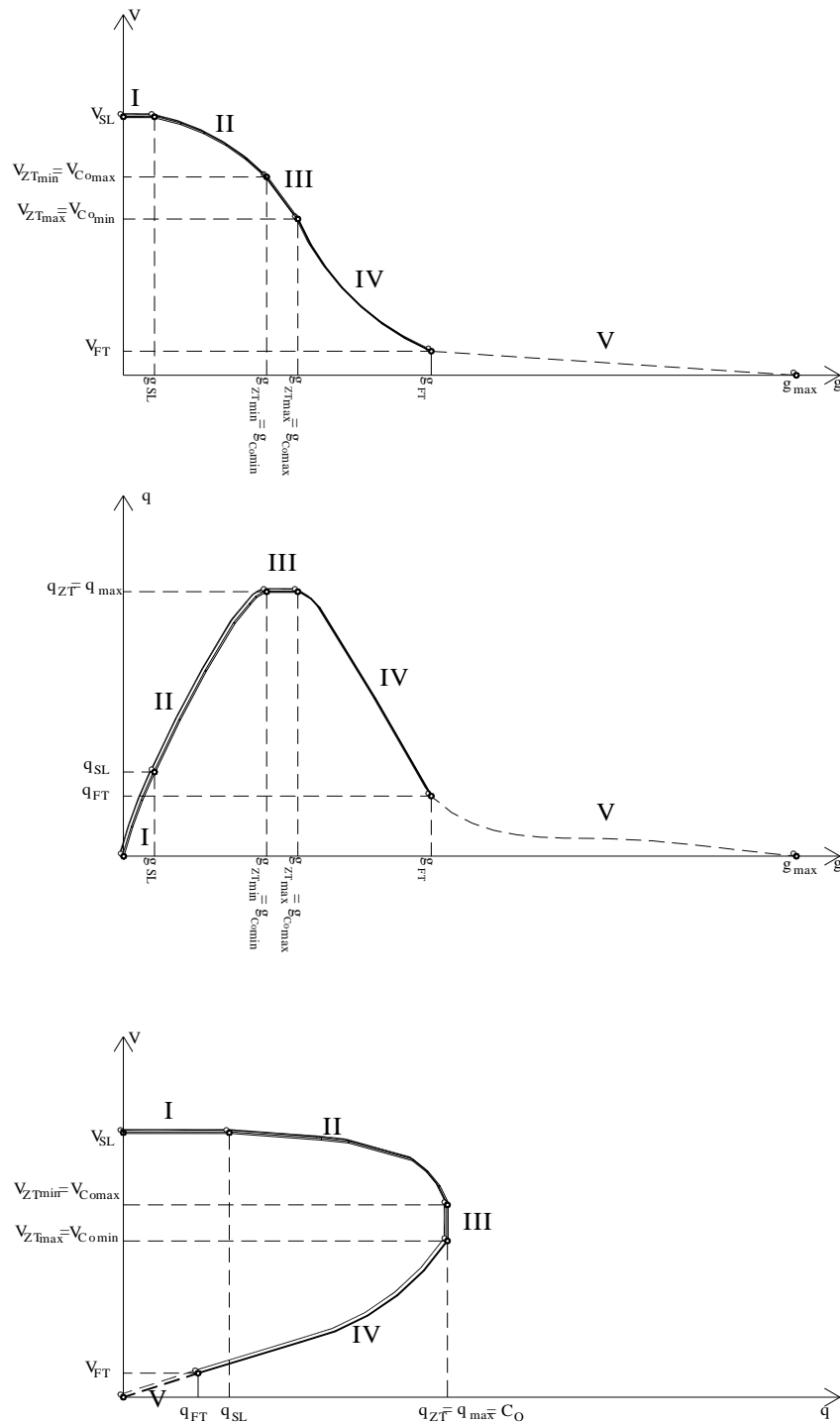


Fig. 2. Graphic presentation of the generalized relationship among the speed, density and flow rate, in real, but nearly ideal conditions

Рис. 2. Графическое представление обобщенных соотношений скорости, плотности и расхода в реальных, но почти идеальных условиях

On the other side, the major factor which impacts on traffic safety on rural highways is mutual effect of mentioned traffic flow variables and geometric characteristics of road infrastructure.

But what happens with various road users needs?

Having in mind this question, it must be said that, most analysis of the relations between traffic flow characteristics and safety, are established on homogenous traffic conditions that means traffic flows which consist of primarily cars or motorized vehicles of similar characteristics.

Proper form of the relationship ought to be based on various road users with own travel and traffic patterns. This is especially important for urban areas in developing countries which are characterized by mix of non-motorized and motorized modes, and mixed land-use patterns.

Factors which have the great impact on traffic safety on urban roads can be classified as:

- street design and control conditions,
- various road users, such as pedestrians and cyclists,
- various aspects of driver behavior.

When it is a question of people as the participants in realizing of transport services, it ought to be stressed that recent investigations are focused on safety of so called **vulnerable road users, (VRU), first of all pedestrians and cyclists**, because they are the largest groups involved in road accidents. This is primarily related to developing countries.

The guideline principles which ought to be followed are:

- developing an efficient data bank in order to obtain precise information about the characteristics of accidents in which vulnerable road users are involved,
- undertaking the measures for protection of VRU which are sharing the same land with motorized participants in traffic flows.
- respecting VRU needs in the whole process of road network development, first of all in the planning and design stages,
- improved road hierarchy in accordance with pedestrians and vehicles transport and traffic demands.

4. CONCLUSIONS

In spite of the facts which point out to better situation in safety on European roads, (mid-term review of the European Commission's 2001 Transport White Paper), it is obvious that **sustainable safety** remains an important objective of current European transport policy.

The **basic elements** of such approach are **users and their various needs in the process of realizing the transport services**.

Road transport is characterized with low safety level. So, plenty of measures are undertaking in order to decrease the number of road-transport fatalities.

This paper is focused on improved management of traffic flows as an important aspect in sustainable road network development.

User oriented approach in advancement of sustainable transport safety, **is the basic prerequisite for successful realizing of various phases in road network development process.**

A number of **key actions** are taken **towards higher safety level** of so called **vulnerable road users, such as, pedestrians and cyclists.**

In accordance with **special transport needs of this class of road users, improved land use planning and well-designed road classification should be taken into consideration in the frame of the earliest planning stages.**

Design standards of various road facilities, **ought to be based on motorized vehicles and vulnerable road user behaviour as well.**

In order to improve transport safety, **methods and proceedings for road construction and maintenance, should be developed and undertaken in connection with non-motorized traffic demands.**

Permanent education of motorized and non-motorized users parallel with engineering measures, is prerequisite for successful accomplishment of mentioned actions.

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