EFFECTS OF IMPROVED TRAFFIC MANAGEMENT ON SUSTAINABLE DISTRIBUTED ROAD TRANSPORTATION SAFETY BASED ON ASIAN EXPERIENCES

SPOSOBY SKUTECZNEGO ZARZĄDZANIA ROZPROSZonym TRANSPORTem KOŁOWYM UKIERUNKOWANYM NA BEZPIECZEŃSTWO Z PERSPEKTYWY KRAJÓW AZJI

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Abstract: Knowledge of the improved traffic management and its effect on road safety is an important component in the process of sustainable road network development. Having in mind that so many road traffic casualties occur, a key priority in transport policy is making highways as safe as possible. The mentioned objective is attained by means of sustainable safety. The paper focuses on sustainable road safety and his principles, based on selected Asian countries experiences. The knowledge base covers institutional responsibility of road safety, the development of a road safety action plan, raising awareness and understanding of road safety problems, road crash data systems, road safety education and training, traffic safety legislation, enforcement of traffic laws and monitoring and evaluation of the effectiveness of road safety activities. In order to improve road transportation safety an organized sustainable approach is needed via concentrated action of all of 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.

Keywords: safety, road transportation, and management

Streszczenie: Wiedza i praktyka w zakresie skutecznego zarządzania rozproszonym transportem kołowym jest kluczowa dla skutecznego kształtowania bezpieczeństwa systemu z uwzględnieniem jego zrównoważonego rozwoju. Publikacja koncentruje swoją uwagę na zagadnienia bezpieczeństwa w ruchu drogowym z perspektywy wybranych azjatyckich krajów doświadczeń i ewolucji z uwzględnieniem krajów rozwiniętych.

Słowa kluczowe: bezpieczeństwo, transport kołowy, zarządzanie
1. Introduction

Everyone recognizes that in today’s world, transportation is a key element of the global economy. It has changed the face of employment, trade, family life and health care bringing benefits that were unimaginable 100 years ago. 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.

However, the price we are paying in form of road crash mortality and morbidity for such benefits is too high, in world scale; it is the cause of loss of more than 1.2 million lives and about 50 million injuries annually [1]. On a regional basis, road fatality take the greatest toll on the Asia and Pacific region where 44 percent of the world’s road fatality occur and only 12 percent of the total occur in Central/East Europe (Figure 1).

In recent decades, the number of road users killed in accidents has increased rapidly in Asia, mainly due to the rapid rate of motorization. The increase in the fatality rate has continued despite the fact that vehicles have become safer. The ESCAP (Economic and Social Commission for Asia and Pacific) secretariat estimates that by 2020 about two thirds of the world’s road deaths (or 610,000 road deaths) could occur in the ESCAP region (see Figure 2).

Figure 3 illustrates that the increase in the number of deaths on Asia’s roads has been almost entirely due to rapid motorization. The overall number of road traffic fatalities (adjusted for underreporting and excluding two- and three-wheeled vehicles) per 10,000 motor vehicles in the ESCAP region has remained stable at around 20 or twice the world average since the early 1990s.

Fig. 1 Estimated road fatality regional distribution (1999) [2].
The nature of road safety issues in the developing countries of the ESCAP region differs significantly from that in developed countries. In Asia, most of those killed or injured in road accidents are vulnerable road users, such as pedestrians and motorcyclists. In South Asian countries, typically more than 50 per cent of all road fatalities are pedestrians. In East and South-East Asian countries, more than two thirds of the victims are motorcyclists. In contrast, casualty rates in North and Central Asian countries are typically similar to those of the member countries of the Organization for Economic Cooperation and Development (OECD). Yet all the developing countries of the ESCAP region have higher fatality rates than the member countries of OECD.

Fig. 2 Number of road traffic fatalities from 1990 to 2020 [3]

Fig. 3 Number of motor vehicles and number of road traffic fatalities [3]
Despite the growing burden of road traffic injuries, road safety has received insufficient attention at both the international and national levels. The reasons include lack of general awareness and specific information on the scale of the problem, on the health, social and economic costs of road traffic crashes, and on the interventions that can prevent crashes or reduce the harm they cause.

Another reason is that the problem of road traffic crashes and an injury does not “belong” to any specific agency, either at national or international levels. Instead, responsibility for dealing with the various aspects of the problem – including the design of vehicles, the design of road networks and roads, urban and rural planning, the introduction and enforcement of road safety legislation, and care and treatment of crash victims – is divided among many different sectors and groups. There has usually been no leader to ensure that they coordinate their efforts and address the problem as a whole. In this environment, it is not surprising that political will has frequently been lacking to develop and implement effective road safety policies and programmes.

In order to improve such situation, a national medium or long term Road Safety Plan is a prerequisite for achieving sustainable improvements in road safety. The plan should set measurable long term and mid-term road safety targets, build capacity of local institutions, and provide alternative sources of financing for road safety measures. Improving road safety requires the participation of many different organizations and sectors. No one sector working alone can effectively reduce the number of road casualties.

2. The Principles of Sustainable Safety

The objective of sustainable safety is to prevent road crashes from happening and where this is not feasible, to reduce the incidence of (serious) injuries. This can be achieved by a proactive approach in which human characteristics are used as the starting point: a user-centric system approach. On the one hand these characteristics refer to human physical vulnerability and to human (cognitive) capacities and limitations on the other. People regularly make errors unintentionally and are not always able to perform their tasks as they should. Furthermore, people are also not always willing to comply with rules and violate them intentionally. By tailoring the environment (e.g. the road or the vehicle) to human characteristics, and by preparing the road user for traffic tasks (by training and education), we can achieve an inherently safe road traffic system.
The most important features of inherently or sustainable safe traffic that latent errors in the traffic system are (gaps in the system that result in human errors or traffic violations causing crashes) as far as possible, prevented and that road safety depends as little as possible on individual road user decisions. The responsibility for safe road use should not be placed solely on the shoulders of road users but also on those of who are responsible for the design and operation of the various elements of the traffic system (such as infrastructure, vehicles and education).

The sustainable safety vision of road safety is based on five principles. These five principles refer to the functionality of roads, the homogeneity of mass and/or speed and direction, physical and social forgivingness, recognition and predictability of roads and behavior, and state awareness.

The five principles of sustainable safety are the essence of a sustainable safe traffic (Wegman & Aarts, 2006; see Table 1) [4]. The following points are the real meaning of the sustainable safety vision:

- the prevention of (serious) crashes, and where this is not possible, then almost total elimination of the risk of severe injury,
- the premise that man is the measure of all things due to his physical vulnerability and cognitive capabilities and limitations (such as fallibility and offence behavior),
- an integrated approach to the elements human-vehicle-road which is tuned to the human measure,
- a proactive approach to bridging gaps in the traffic system.

Table 1. The five sustainable safety principles with a short description

<table>
<thead>
<tr>
<th>Sustainable safety principles</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functionality of roads</td>
<td>Mono-functionality of roads as flow roads, distributor roads in an hierarchically structured road network</td>
</tr>
<tr>
<td>Homogeneity of masses and/or speed and direction</td>
<td>Equity in speed, direction, and masses at medium and high speeds</td>
</tr>
<tr>
<td>Forgivingness of the environment and of road users</td>
<td>Injury limitation through a forgiving road environment and anticipation of road user behavior</td>
</tr>
<tr>
<td>Predictability of road course and road user behavior by a recognizable road design</td>
<td>Road environment and road user behavior that support road user expectations through consistency and continuity in road design</td>
</tr>
<tr>
<td>State awareness by the road user</td>
<td>Ability to assess one’s capability to handle the driving task</td>
</tr>
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</table>
3. Sustainable Development of Safety Management System

A safety management system operating effectively must provide measurements of the use of the road network, assessment of risk levels on the network, monitoring of safety performance, prioritisation and implementation of treatments and regular documentation of outcomes [9]. Ultimately in pursuing the notion of sustainable development the results of applying the SMS (Safety Management System) approach should be able to demonstrate the following trends with regard to road safety engineering.

Primary trends may be defined as:
- reducing levels of risk of death and serious injury on the road network,
- reducing the incidence of death and serious injury attributable directly to road and traffic management practices.

Demonstrating such progress should be reflected in specific trends such as:
- reducing levels of speed towards those that are more appropriate for the different physical environments and the road user mixes they accommodate,
- reducing the proportion of the road network which presents hazards to road users beyond their physical ability to withstand the injuries that would occur,
- reducing the extent to which road users of different vulnerabilities and performance must use the same sections of the network at the same time.

Application of road safety engineering practice through approaches such as SMS cannot stand alone in attempting to achieve sustainable development of road safety management. The structured approach must be pursued in the context of transport policy settings which influence transport demand and operations, the development of the transport infrastructure and help set acceptable levels of risk.

4. The Principles of Sustainable Road Network Development

There are many definitions for sustainability. One of the most useable is: “Sustainable development is a pattern of resource use that aims to meet human needs while preserving the environment so that these needs can be met not only in the present, but also for future generations.” [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 that 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 and co-modality.

Developing an efficient, well-integrated and complete road network is the base for the increasing mobility of the road transport users. Transport systems exist to provide social and economic connections, and people quickly take up the opportunities offered by increased mobility. The advantages of increased mobility need to be weighed against the environmental, social and economic costs that transport systems pose. 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 factor in the process of road network management.

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

Traffic takes place in complex system consisting of road infrastructure, vehicle operators, vehicles and weather conditions. Each of these factors is complex and undergoes systematic and random changes. Safety is provided in that system by the means of safety in soft (law, regulations and local rules) and hard form (traffic signals, barriers, etc.). So having in mind the characteristics 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 improved management of traffic flows on it; vehicle construction and technology in order to satisfy various user 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 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 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 the trips. Road transport is characterized with low level of traffic safety in comparison with the other transport modes, which is important and prerequisite for accomplishment of the other. On the other hand, most passengers and goods flows go by roads. Having in mind this transport mode is the essential part of each individual life. 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 that will give a high level of road safety. These are some of the most important principles of sustainable road safety:

- 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 is 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. 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 behavior.

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.

On the other side, the major factor which impacts 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.

5. Asian Road Safety Map Discussion

In many parts of developing Asia, encroachment onto the right-of-way is a common problem. After a road is developed many people move in looking for business opportunities, thereby creating ribbon development along the roads. Pedestrians, bicycles, pushcarts, motorcycles, cars and trucks compete for road space and thus create serious safety problems.

The Asian Highway comprises more than 141,000 km of trunk roads passing through 32 ESCAP member States. Table 2 [7] shows the Asian Highway road classifications. Primary and Class I roads are median separated and therefore safer than Class II and Class III roads, which are two lanes without a divider.

<table>
<thead>
<tr>
<th>Classification</th>
<th>Description</th>
<th>Pavement type</th>
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<tbody>
<tr>
<td>Primary</td>
<td>Access-controlled highways</td>
<td>Asphalt or cement concrete</td>
</tr>
<tr>
<td>Class I</td>
<td>4 or more lane</td>
<td>Asphalt or cement concrete</td>
</tr>
<tr>
<td>Class II</td>
<td>2 lanes</td>
<td>Asphalt or cement concrete</td>
</tr>
<tr>
<td>Class III</td>
<td>2 lanes</td>
<td>Double bituminous treatment</td>
</tr>
</tbody>
</table>

Upgrading Asian Highway segments to class I and to primary roads (access-controlled) in particular the latter has significant safety benefits even when higher traffic volumes are taken into account.

The Ministerial Declaration on Improving Road Safety in Asia and the Pacific builds on the Intergovernmental Agreement on the Asian Highway Network and essentially extends key elements of the road safety framework of the Association of Southeast Asian Nations (ASEAN) to the whole ESCAP region. In particular, the Declaration includes an overall goal to save 600,000 lives and prevent a commensurate number of serious injuries on the roads of Asia and the Pacific over the period 2007 to 2015. Members and associate members of the Commission are invited to address road safety in the following areas (eight ESCAP goals):

- making road safety a policy priority,
- making roads safer for vulnerable road users, including children, senior citizens, pedestrians, non-motorized vehicle users, motorcyclists, and persons with disabilities,
- making roads safer and reducing the severity of accidents (building
“forgiving roads”),
- making vehicles safer and encouraging responsible vehicle advertising,
- improving national and regional road safety systems, management and enforcement,
- improving cooperation and fostering partnerships,
- developing the Asian Highway as a model of road safety,
- providing effective education on road safety awareness to the public, young people and drivers.

Road traffic crashes are predictable and can be prevented. Many high-income countries have shown sharp reductions in crashes and casualty numbers over the past couple of decades by adopting a systems approach to road safety that emphasizes environment, vehicle and road user interventions, rather than solely focusing on direct approaches aimed at changing the behavior of road users. Although solutions for low-income and middle-income countries may differ from those countries that have a longer history of motorization, some basic principles are the same. These include, for example, good road design and traffic management, improved vehicle standards, speed control, the use of seat belts and the enforcement of alcohol limits. The challenge is to adapt and evaluate existing solutions, or else create new solutions in low-income and middle-income countries. Vision Zero in Sweden and the sustainable safety programme in the Netherlands [8] are examples of good practice in road safety. Such good practice can also have other benefits. It can encourage healthier lifestyles involving more walking and cycling and can reduce the noise and air pollution that result from motor vehicle traffic. Colombia is an example of a developing country that is beginning to implement a similar strategy.

6. Conclusions

To develop a road safety in a sustainable manner we need to focus on basic elements of this approach that 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.
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 behavior as well.

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

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References

3. ESCAP: Asia-Pacific road safety database
4. SWOV Institute for Road Safety Research, Netherlands,