Motor Vehicle Safety Technologies in Relation to the Accident Rates

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Abstract. The increasing need for human mobility is one of the indicators of wealthy society and economic success of human behaviour. Development of transportation in all its sectors is also connected with the evolution of society. Negative aspects caused by this development are the occurrence of road accidents, energy efficiency and traffic congestions. The response to these major challenges cannot be limited to traditional measures. It is important to present and evaluate the impact of intelligent vehicle systems on road transportation safety. Therefore, it is necessary to change and modify the current situation that would lead to decrease in number of accidents that occur on the roads every year. Number of accidents is a good safety indicator. This paper identifies and presents different safety technologies used in modern motor vehicles. Use of such technologies and vehicle to vehicle communication as a part of cooperative systems is crucial in achieving this goal. The aim is to build a common understanding of the asset that cooperative systems and new safety features provide in road transportation and later create a proper environment for their deployment on European roads.

Keywords: Transport safety · Motor vehicles safety · Cooperative systems

1 Introduction

Road transportation today faces enormous challenges. Demand for personal mobility is increasing while imposing a high cost on society. Road transportation safety refers to the methods and measures used for reducing the risk of a person using the road network being killed or seriously injured. Road traffic crashes are one of the world's largest public health and injury prevention problems. The problem is all the more acute because the victims are overwhelmingly healthy prior to their crashes. Numerous initiatives by European Commission are underway, for example, to raise awareness and to make motor vehicles technically safer. High-tech in-vehicle safety and efficiency features represent an opportunity to improve this situation. Their potential to bring a positive impact on transportation safety is well known. These technologies have not penetrated the market, solely due to a lack of understanding about the potential benefits to driving behaviour [1].

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2 Road Transportation Accident Rates

Road traffic accident also known as traffic collision or motor vehicle collision takes place when a vehicle collides with another vehicle, pedestrian, animal or other stationary obstruction such as a tree or utility pole. Road traffic accident may have many different results. Few of them are injury, death, vehicle damage and property damage. Road accidents are caused mainly by humans when they neglect or refuse to follow laid down rules, signs and regulations concerning the use of roads. An estimate of over 1.2 million people are killed in road crashes each year and as many as 50 million are injured [2].

Smeed's Law is an empirical rule relating traffic fatalities to traffic congestion as measured by proxy of motor vehicle registrations and country population. Smeed interpreted his law as a law of human nature. The number of deaths is determined mainly by psychological factors that are independent of material circumstances. People will drive recklessly until the number of deaths reaches the maximum they can tolerate. When the number exceeds that limit, they drive more carefully [3]. This law provides a good example on how people think while driving.

A study by Rumar using crash reports from the United Kingdom and U.S. as data, found that 57 % of crashes were due solely to driver factors, 27 % due to combined roadway and driver factors, 6 % due to combined vehicle and driver factors, 3 % due solely to roadway factors, 3 % due to combined roadway, driver and vehicle factors, 2 % due solely to vehicle factors and 1 % due to combined roadway and vehicle factors.

Human factors in vehicle collisions include all factors related to drivers and other road users that may contribute to a collision. Examples of such factors include driver behaviour, visual and auditory acuity, decision making ability and reaction time. Driver impairment describes factors that prevent drivers from driving at their normal level of skill. Common impairments are for example alcohol, physical impairments such as poor eyesight, age, fatigue (sleep deprivation), drug use and distraction such as conversations and operating a mobile phone while driving. Road design is crucial for safe driving [4].

Fatal injuries include all the victims who die within 30 days of the accident as a result of injuries sustained. Injuries are not always correctly classified by severity in police accident reports. Definitions of injuries are often not clear and there is no standardization whether in EU or U.S. Long term impacts of traffic injuries are poorly documented. There are reasons to believe that a number of people living with lasting impairments as a result of traffic injury is likely to be increasing [5]. Property damage only (PDO) is the most common type of accident. The only negative aspect of such an accident is financial loss without any injuries.

Figure 1 shows that number of fatal accidents is decreasing in EU and Slovakia. On the other side, in 2012 the number increased in both, USA and in the state of Texas. It shows that actions of European Union led to the improvement in terms of safety for all network users.

One approach to understand accident severity is to investigate the relative frequency of accident severity. This concept can be visualized as a pyramid, where fatal accidents stand at the top of such a pyramid. These accidents are relatively rare. At the base of the

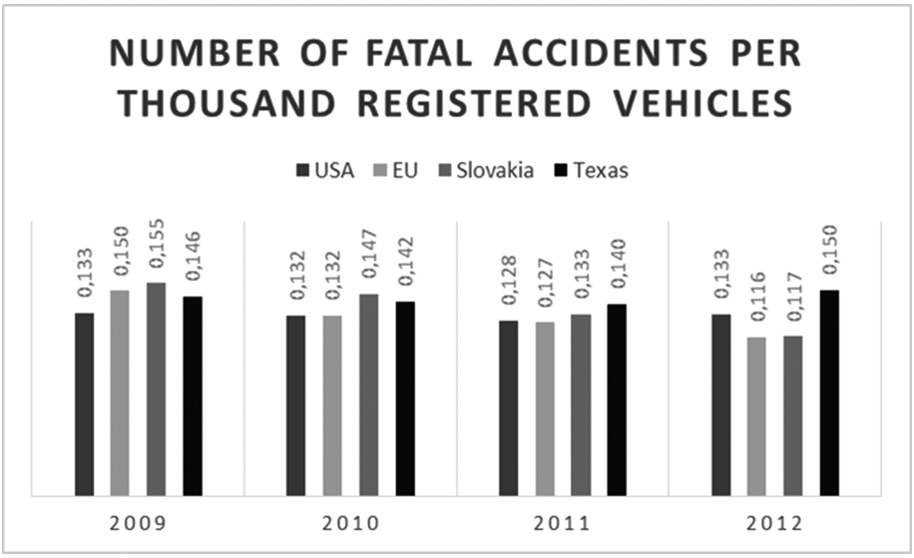

Fig. 1. Number of fatal accidents per thousand registered vehicles [own study based on [6–9],

pyramid there are traffic conflicts such as interactions between road users which do not result in an accident. The levels in between consist of accidents resulting in severe and slight injuries, as well as accidents that only result in property damage [10].

Road traffic accidents generally fall into one of four common types:

- Lane departure crashes, which take place when a driver leaves the lane they are currently in and collide with another vehicle or a roadside object (these include head-on collisions and run-off-road collisions)
- Collisions at junctions (rear-end collision and angle or side impacts)
- Collisions involving pedestrians and cyclists
- Collisions with animals

Despite this division of types of accidents there are other types that occur and are important to mention. Rollovers are not very common, but lead to greater rates of severe injuries and deaths. Some of these are considered to be secondary events that occur after a collision with a run-off-road crash or a collision with another vehicle.

3 Safety Systems in Motor Vehicles

Evolving technological advancements have great potential for improving the safety of road transportation. Number of safety and security proposals are developed by motor vehicle producing companies. These technologies are being developed in order to protect drivers as well as other users of the network. Their impact is not noticeable right now. In the next years to come most of them will become a routine part of all the new vehicles built worldwide. Some of the functions that assist the driver in detecting hazards and avoiding most types of accidents are:

– Lane departure warning systems (LDW) which monitor the position of a vehicle within a lane and are set to warn the driver if the vehicle deviates or is about to deviate outside the lane unexpectedly. The system maintains the vehicle position by detecting lane markings or street boundaries via a video sensor. A warning occurs only above a certain minimum speed (Fig. 2).

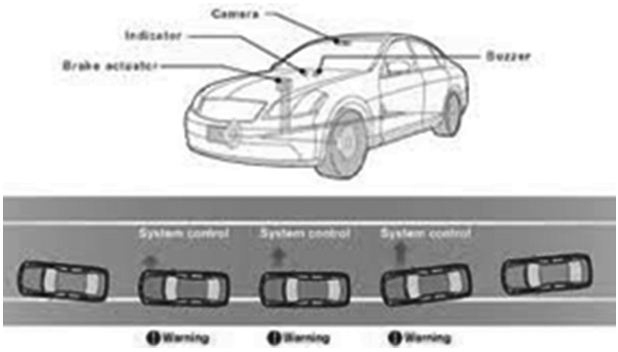

Fig. 2. Lane departure warning system [17]

– Collision warning system (CWS) monitors the roadway ahead and is supposed to warn a driver via sound and light signals when potential danger such as another vehicle or object is detected in the same lane and thus can help avoid rear-end impacts or minimize the effects of these type of collisions. The brakes are pre-charged to prepare for efficient braking if the risk of a collision increases despite the warnings.
– Adaptive cruise control (ACC) systems are in-vehicle electronic systems that can be integrated with CWS and can automatically maintain a minimum following interval to the vehicle in front in the same lane. If there is no vehicle ahead it works as a conventional cruise control so the speed is set by the driver.
– Rear object detection systems which detect moving and stationary objects located within a specific area behind the vehicle can be integrated with other sensors such as side object detection sensors to cover other blind spots around the vehicle. European Commission estimated that blind spot problem causes about 500 fatalities a year on Europe's roads. Because of this problem a directive that requires rear-view mirrors to be upgraded in order to reduce this blind spot was implemented [11].
– Safe human machine interaction for navigation systems. All in-vehicle information and communication systems intended for use by the driver while the vehicle is in motion, for example navigation systems, essential safe design and use aspects for the human/machine interface need to be taken into account. Several different types of system with different display positions and technologies such as head-up or separate detachable display are currently on the market [13].
– Fuel efficiency advisor is a transportation information system that provides in real time the current location of motor vehicles, their fuel consumption, driver times, service intervals and much more. Fuel efficient driving is supported through on-board functions for the driver as well as follow-up reports in the back office system [13].

– Impairment warning (IW) alerts tired and distracted drivers. A camera monitors the movements of the car between the lane markings and calculates the risk of the driver losing control of the vehicle. A message on the display advises the driver to take a break [13].
– Vehicle stability systems (VSS) monitor lateral acceleration from on-board sensors to reduce rollovers due to excessive speed in a curve and prevent loss of control crashes due to instability of a vehicle. They can be used as passive (warning of potential instability) or active systems (intervene by reducing the throttle and applying different brake pressure in order to correct instability) [12].

4 Cooperative Systems

The main goal of cooperative systems is to increase road safety using wireless communication among vehicles and also between the vehicles, drivers and the roadside infrastructure. This is an attractive solution contributing to the European goal of safer, cleaner and more efficient and sustainable traffic solutions. Cooperative systems are new generation of intelligent transport systems (ITS) (Fig. 3).

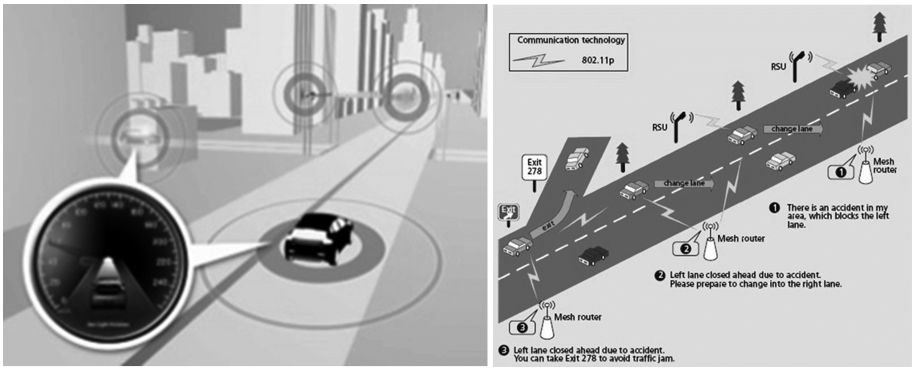

Fig. 3. Cooperative system working principle [18]

ITS is still a young discipline, varying from country to country in levels of acceptance, take-up and local applicability. It is a generic term for the integrated application of communications, control and information processing technologies to the transportation system. The resultant benefits save lives, time, money, energy and the environment. The term "ITS" is flexible and capable of being interpreted in a broad or narrow way. "Transport telematics" is a term used in Europe for the group of technologies that support ITS. ITS covers all modes of transport and considers all elements of the transportation system – the vehicle, the infrastructure, and the driver or user, interacting together dynamically. The overall function of ITS is to improve decision making, often in real time by transport network controllers and other users, thereby improving the operation of the entire transport system. The definition encompasses a broad array of techniques and approaches that may be achieved through stand-alone technological applications or as enhancements to other transportation

strategies. Information is at the core of ITS whether it is static or real time traffic data or a digital map. Many ITS tools are based on the collection, processing, integration and supply of information. Data generated by ITS may provide real-time information about current conditions on a network, or on-line information for journey planning, enabling highway authorities and agencies, road operators, public and commercial transport providers and individual travellers to make better informed, safer, more coordinated and more 'intelligent' decisions or 'smarter' use of networks. Safety benefits include safety systems such as adaptive speed control, collision detection and avoidance, enhanced vehicle safety systems and cooperative vehicle highway systems (CVHS). European Union have invested massive public funds in research and technological development of this system. The path to widespread deployment of ITS is not without its challenges. Much of the technology is well proven but increasingly there is a realization that the more difficult issues are social, institutional and political [14].

5 Vehicle - to - Vehicle Communication

Vehicle-to-vehicle (V2V) communications comprises a wireless network where automobiles send messages to each other with information about their actions. This data include speed, location, and direction of travel, braking and loss of stability. Vehicle-to-vehicle technology uses dedicated short-range communications standard (DSRC). The range is up to 300 meters or 1000 feet or about 10 s at highway speeds. On the first cars, V2V warnings might come to the driver as an alert, perhaps a red light that flashes in the instrument panel, or an amber then red alert for escalating problems. It might indicate the direction of the threat. All that is fluid for now since V2V is still a concept with several thousand working prototypes or retrofitted test cars. Most of the prototypes have advanced to stage where the cars brake and sometimes steer around hazards [15] (Fig. 4).

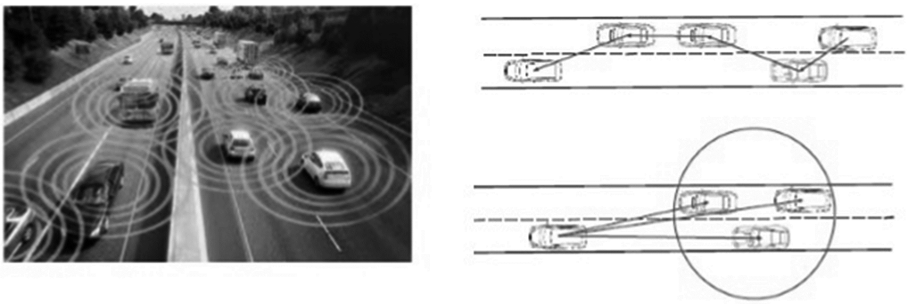

Fig. 4. Vehicle to vehicle communication [19]

The goal of V2V communication is to prevent accidents by allowing vehicles in transit to send position and speed data to one another over an ad hoc mesh network. Depending upon how the technology is implemented, the vehicle's driver may simply receive a warning should there be a risk of an accident or the vehicle itself may take pre-emptive actions such as braking in order to slow down. V2V technology enables an ubiquitous 360 degree awareness of surrounding threats. V2V is an important part of the intelligent

transport system (ITS). An intelligent transport system will use the data from vehicle-to-vehicle communication to improve traffic management by allowing vehicles to also communicate with roadside infrastructure such as traffic lights and signs. The technology could become mandatory in the not-too-distant future and help put driverless-cars on the roads [16].

6 Conclusion

Cooperation of all drivers is crucial for the prevention of accidents. From this situation comes a need for control of road transportation by all the responsible authorities. Road traffic safety refers to the methods and measures for reducing the risk of a person using the road network being killed or seriously injured. The relatively low level of fatalities in rail, sea and air transport accidents stands in sharp contrast to the number of road fatalities that occur every year. Major progress has however been made in road safety, having as a result a noticeable yearly decrease in road fatalities throughout the years. Numerous initiatives are underway, for example to raise awareness and to make motor vehicles technically safer. The number of accidents is a good safety indicator. There is still a need to enforce innovative rules, regulations and systems into the vehicles to minimize this number. Once the vehicles will be equipped with the newest technologies and they will be able to communicate with each other there is a strong belief that number of accidents will decrease rapidly. These technologies help drivers in critical situations and when they pass for example a collision site they are able to send information about their occurrence to the vehicles approaching a dangerous place in the network. It means that almost 30 % of driver based collisions could be avoided by the use of cooperative systems. [18] In 2012 there were 28126 fatal accidents on European roads. With the use of vehicle to vehicle (V2V), vehicle to infrastructure (V2I) and vehicle to other type of device (V2X) communications this number could be lowered to as low as 19688 fatalities. To be sure about this potential decrease we need to gain a better understanding of the short and long term socio-economic impact of such systems on safety and driver comfort.

Traffic calming in the cities is a process reflecting the efforts to achieve new quality of life as well as the implementation of modern transport policy at European level. In practice, traffic moderation may come in various forms according to the type of area and road, and to the requirements of relevant citizens. It is appreciated that after many years of hesitation, traffic moderation is developing in Slovakia too. The common task is the advertising and edification of public and the presentation of good practices. Nevertheless, the trend is definitely in the direction of joining the European efforts for humanisation of transport system.

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