ON INVESTIGATION OF TRAFFIC SAFETY BASED ON STATISTICAL DATA REGARDING VEHICLE TYPE AND ROAD INFRASTRUCTURE

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Abstract

Safe traffic is a key factor f or both social players and the sustainable development of the economy. The various interest groups involved i n traffic each have their ow n role in making our roads safe. The large number of traffic accidents and their grave consequences represent a real problem all over the world (see, for instance, the incredibly crowded metropolises of Southeast Asia or the me gacities of Latin-American). A successful innov ative activity in this field performed on a worl dwide scale contributes t o solving a critical social and economic issue. Due to the more easily available European statistical data, the paper is goi ng to present the causes of accidents and examine possible solutions.

A 2001 objective of the European Union requires a 50 percent reduction in the number of fatal road accidents by 2010. Although a number of effective measures have been implemented in the field of traffic safety, the number of road accidents is still unacceptably high in the EU: a total of 1.3 million accidents per year result in close to 40,000 deaths and 1.7 million injuries. There is a large body of statistical data av ailable (both from Hungary and fr om Europe) and several comprehensive researches discuss the types of acc idents. Available analyses are going to made on what kind of active or passive vehicle safety systems coul d have helped avoid the accidents. These analyses have and still define the main directions for legislation and technical developments.

***Keywords**: traffic, safety, accident, statistics, assistant systems*

1. Introduction

Statistically, the primary cause of fatal accidents is traffic participants' bad behaviour (speeding, alcohol consumption, fatigue, unfastened seat belts, etc). In addition to encouraging public road travellers, another key objective is to create a safer vehicle fleet using technical innovations and to develop the public road infrastructure based on the latest infocommunication technologies. When analysing accident statistics, another unfavourable tendency is that even though the number of accidents caused by passenger vehicles is steadily decreasing (although not as drastically as expected), there has been a much lower change in the number of accidents involving commercial vehicles since the European Public Road Safety Charter was issued in 2001.

Analysis of European accident statistics shows that over two-thirds of all accidents resulting in fatalities or serious injuries could be prevented if vehicles were equipped with different driver assistance systems. The most important of these systems are ESP (Electronic Stability Program), LDW (Lane Departure Warning) and ACC (Adaptive Cruise Control). These systems are available as options for passenger cars and they even have versions adapted to commercial vehicles. Unfortunately, these have not yet become as common for commercial vehicles as they are for passenger cars, or should be to avoid accidents (or mitigate their impact).

Some of the next generation driver assistance systems are close to prototype or end-product stage for passenger cars. However, they would be very complicated and time-consuming to adapt for a commercial vehicle platform and would require serious innovation due to the different considerations for vehicle dynamics, manufacturing technology and operating conditions and the various business models. Having realised this, European decision-makers now have a schedule according to which it will only be permitted to launch those new motor vehicles that are equipped with the appropriate safety systems.

Such a sharp turn in the concept is justified by a number of reasons. The first is that there are more direct intervention options on the vehicle side and we are less dependent on other traffic participants (e.g. the communications based vehicle infrastructure presents a viable solution only i.e. a large number of participants are equipped with these). Traffic safety is not only a social issue but also a business category. And while the business model is quite clear on the vehicle side, coordination on the infrastructure side is still in its initial stages due to the multi-player market. Another positive effect of managing these issues from the vehicle side is that it would increase the throughput of the existing infrastructure and thereby decrease environmental pollution.

2. Road infrastructure and accident statistics

Road infrastructure is the central element of a road transport system. It can be defined as the basic facilities, services and installations needed for the functioning of transport on highway, roads, and streets. Road infrastructure is a wide area and covers land use and network planning, (re)construction and design of road sections and intersections, signing and marking, maintenance, and, last but not least, quality assurance procedures like safety audits, safety impact assessments and safety inspections. In general, the road infrastructure would need to be designed and operated in such a way that road users understand what they can expect and what is expected from them, taking into account the limited human information processing capacity and resulting mistakes human beings are capable of.

Land use and network planning form the basis of a safe road infrastructure. Elements that need consideration are the distance between work and housing and the location of daily services, such as schools, homes for the elderly, medical centres and shopping areas, in relation to living areas. Furthermore, it is important that for longer and frequent trips, the fastest route coincides with the safest route, i.e. that the required distance on the more dangerous lower order roads is limited in favour of the safer higher order roads. One important improvement can be achieved by reconsidering the current road classification, allowing for a limited number of road categories only and avoiding multi-functional roads, and subsequently ensuring that the design and lay-out of a road reflect its true function. The latter may require upgrading some roads and downgrading other.

There are numerous handbooks on road design and road construction, some of them specifically focusing on designing for safety, e.g. the Highway design and traffic safety engineering handbook and the Road safety manual. Two central requirements for a safe design are:

- the design characteristics need to be consistent with the function of a road and the behavioural requirements (e.g. speed),
- the design characteristics need to be consistent along a particular stretch of road.

A part of the road that should not be forgotten is the roadside. Obstacles alongside the road, such as trees, severely aggravate the consequences of a crash, once a vehicle runs off the road. Paved shoulders increase the opportunity for a driver to correct and return to their lane in time. Obstacle avoidance roadsides or roadsides protected by guard rails prevent secondary collisions once a driver cannot correct in time. Flexible or break-away roadside fixtures such as light poles and signs reduce the chance of serious injury in case of a collision. When safety is considered from the beginning in the stages of the planning and design, the chance that remedial measures are required after implementation is small. Nevertheless, it is advisable to monitor the crash statistics in order to identify high risk locations. Further inspection of those sites often clarifies the problem and the ways to improve safety, if possible through low-cost engineering measures. Specific tools and procedures are needed to prioritise the remedial measures and implement the most cost-efficient ones at the appropriate hazardous locations. Junctions often have much higher accident frequencies than other road sections because of their numerous potential points of conflict. One way to mitigate crash risk at junctions is to grade-separate them. Where this is not feasible or justifiable, the implementation of roundabouts has proven to be a safe and efficient option which has gained popularity in many Member States over the last years.

Collisions between motor vehicles and unforgiving roadside objects such as trees, poles, road signs and other street fixtures represent an important safety problem. Research and experience indicate that the positioning and design of off-road objects can play a major role in reducing such collisions and the severe consequences that are typically associated with them. Ideally, roads should be designed without dangerous off-road objects. However, this is clearly not possible in all situations and most of the interventions will have to be made on already existing roads. In such a case, manmade objects should be removed, made more forgiving or protected with crash barriers where none of the other options are possible. However, environmental, aesthetic, historical or even emotional value may be attached to roadside trees. In those cases, putting up crash barriers may be preferable to removing the trees, if the space available permits it.

Vehicles and vehicle safety devices play an important role in traffic safety, since they can generate an enduring, sustainable effect. The design of a vehicle affects the protection of occupants in case of a crash and the chance of serious injury to unprotected, vulnerable road users. Additional safety devices, such as seat belts and airbags offer additional protection to car occupants. For two-wheelers, protective clothing and helmets help to mitigate the consequences of a crash. And last but not least, intelligent driver support systems, including in-vehicle, between-vehicle and road-vehicle technologies, help the driver to perform his task safely, preventing errors and violations which may otherwise have resulted in a crash.

The requirements regarding car design are set at an international (UN-ECE) and a European level (EC). However, there is a clear gap between the minimum requirements set by these international bodies and what is potentially possible from a safety perspective. Hence, there are also substantial differences in the safety performances for different cars. Informing the consumers on the safety performance of a car seems to have two consequences. It creates a consumer demand for safer cars and it stimulates car manufacturers to take safety into account as a marketing strategy.

Driver support systems help drivers to drive their vehicle safely, e.g. by warning or intervening when a driver crosses the side line of his driving lane (Lane Departure Warning System), when he approaches too close to the car ahead of him (Adaptive Cruise Control or Collision Avoidance systems), when he exceeds the speed limit in force (Intelligent Speed Assistance), when he or his passengers forget to use a safety belt (Seatbelt Reminders) or when he is about to lose control of the vehicle (Electronic Stability Control). Most of these measures will be made available in new cars by car manufacturers, or as an aftermarket (retrofit) product.

There is a clear relationship between the speed on a particular road and the number and severity of crashes. Reducing speed limit violations will directly affect the safety level. There are various methods to enforce speed limit compliance. Fixed and mobile speed cameras are a well known method of automatic speed enforcement that is applied in many European (and non-European) countries. Another more recent method is section control, currently used in The Netherlands, Austria and the Czech Republic. With section control the average speed over a particular distance (typically several kilometres) is calculated automatically by identifying a vehicle when it enters the control section and when it leaves it, and recording the travel time between those two points. Whereas most section controls are fixed locations, there are also mobile units in use (e.g. in the UK and Austria) particularly at road works zones.

Road safety data are essential for the development of well founded road safety strategies. What exactly is the problem? What are the causes? The more we know about road safety developments and about the underlying causes of those developments, the better we will be able to design and implement the appropriate solutions. Efficiency analyses for assuring that the limited resources are used optimally also require sufficient data. This means that we need reliable data in a number of areas: crash statistics, exposure data, safety performance indicators and data from in-depth crash analysis. Whether the data are reliable largely depends on the data collection method that would need to ensure that the data are correct and representative. Furthermore, good documentation of the data collection method is important as is the accessibility of the data.

Not all road crashes are registered and stored in a database. Generally, fatal crashes are best registered, but even here the data are not complete. The registration rate of fatalities probably ranges between 85% and 95%. As injury severity decreases, the registration rate decreases further. The registration rates of severe injuries generally do not exceed 60%; of slight injuries, it generally does not exceed 30%. Another general phenomenon is that the registration of crashes that do not involve a motorised vehicle is far less complete than that of crashes that do involve a motorised vehicle. Underreporting of crashes leads to an underestimation of the size of the road safety problem. Underreporting of particular types of crashes can also lead to unjustified decisions about road safety measures.

For a good understanding of road safety developments and road safety problems, exposure data are indispensable. Exposure data provide information about how, where and how far people travel and who these people are. Together with crash information, this information allows for calculating the relative risk of travelling in general, or for particular transport modes, particular types of road or particular groups of people.

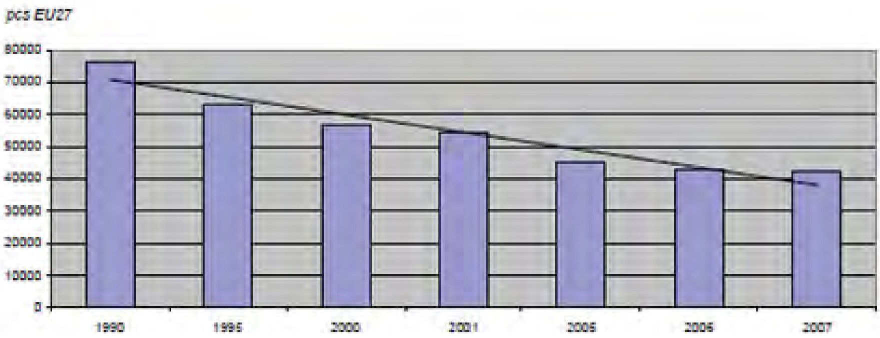


Fig. 4. Number of road traffic accidents (1990-2007)

All over Europe, the number of road crashes has decreased in the last couple of decades (Fig. 4), despite the huge increase in mobility. This means that the risk of getting involved in a road crash, e.g. per kilometre travelled, has declined substantially. But this decline is neither equally distributed over transport modes, nor over road types or road user types. If the risk of some types of travel stays behind, it might be needed to take specific measures to catch up or to prevent that the number of crashes will increase if a risky type of travel is likely to increase in the future. To assess differences in risk and risk developments, it is necessary to monitor exposure on a regular basis. A huge decrease can be seen in Fig. 5 concerning the road fatalities in the EU during the given time interval, as well.

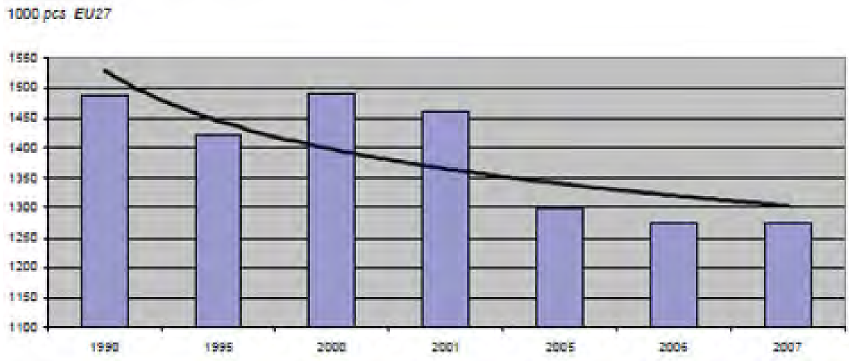


Fig. 5. Road fatalities in the EU (1990-2007)

The number of road traffic victims and the severity of the injuries are the most direct measure of road safety. However, it is also useful to monitor road user behaviour or characteristics of the road that have been proven to relate to the road safety level, e.g. driving speeds, the prevalence of drink driving, seat belt wearing rates, or the presence of forgiving road sides. These types of measures are called safety performance indicators. They provide an indication of the road safety level of a country, and can be used to assess the effects of particular road safety measures. It is important to define safety performance indicators that can be measured reliably and have a causal relationship to the number of crashes or to the injury consequences of a crash.

In-depth crash studies aim to get more detailed information about the causes and the outcome of crashes than available from police records. In in-depth studies, crashes are reconstructed retrospectively by investigations on-the-spot, by interviewing participants and witnesses, by inspecting the damage to the vehicles involved, and by information about the sustained injury. Normally, in-depth studies focus on specific crash types. The extra information is used to detect shortcomings and potential improvements in, for example, vehicle design, road design, road user training, and medical care. In-depth studies are rather common in other transport modes, but less common for road traffic. One of the reasons may be that it is a rather costly type of study. Nevertheless, there is an increasing amount of experience with this type of crash analysis, for example in France, Germany and the United Kingdom and in the framework of the European projects PENDANT and SafetyNET (4).

3. Applied safety and accident prevention systems

Event Data Recorders (EDR) or black boxes monitor a number of variables related to driving behaviour, such as speed, acceleration and deceleration forces, use of lights, gears, seat belts, etc. There are two main EDR types. The crash data recorder collects data for a limited period just before and after a crash and the journey data recorder collects all data during driving. The crash data recorder is generally used to reconstruct the occurrence of a road crash. The journey data recorder is generally used to provide feedback to the drivers about driving style from an environmental viewpoint, a safety viewpoint or both, often in combination with a reward programme. EDR are most often used in trucks, vans and company cars, but increasingly also in private cars. Insurance premium reductions are the most common reward for private car drivers. EDRs for trucks, vans and company cars are generally introduced by the enterprises and firms or lease companies, for example as a part of a 'Safety Culture' programme. The use of EDR in private cars can be stimulated by insurance companies. It appears that EDR have a preventive effect. It has been calculated that EDR in trucks and vans result in an average reduction of 20% crashes and damages, 5.5% fatalities and 3.5% severe injuries. According to another study24 the benefit-cost ratio for companies is 20 for the journey data recorder and 6 for the crash data recorder. A fleet owner can expect a return of investment within a year.

Correcting for underreporting of road traffic fatalities in the Netherlands.

In order to calculate the real number of traffic fatalities, the Dutch Central Bureau for Statistics (CBS) compares three data sources:
- Crash registration by the police;
- Court files on unnatural deaths;
- Files on causes of death from municipal population records.

These three data sources are compared by linking date of birth, date of death, type of unnatural death (suicide, traffic crash, etc.), municipality of death, and gender. The data are stored and can be obtained at CBS. Data can be disaggregated to age group, gender, region, modality, day of the week and month. The aggregated data are also available via the SWOV (Institute for Road Safety Research) website. CBS is responsible for overall data management and for collecting and linking the court and municipality data. The Transport Research Centre of the Ministry of Transport (AVV) is responsible for collecting the police records. CBS and AVV work together to arrive at the final database. The reporting rate of the real number of traffic fatalities, based on the combined three data sources, is very high: 99.4% for 2004. The individual reporting rates were 90% (police records), 88% (court data) and 95% (municipality records). The costs are not exactly known, but assumed to be rather low (a few person months a year), because existing databases can be used.

In-depth analysis of heavy truck crashes in the Netherlands concerns a pilot research project, aiming to explore the possibilities for primary and secondary safety improvements of heavy trucks. In-depth data are collected from inspections at the crash sites, from police and hospital information, and from the road users that were involved. This way the crash can be reconstructed and analysed. During the pilot, data of 30 crashes were collected. In addition, 30 control group locations were investigated to control for the effect of exposure. The police notified the researchers when a relevant crash had happened. Within 24 hours, the crash location was inspected and questionnaires were sent out to involved parties and witnesses. Vehicles were inspected later. The police collected the data according to their own procedures and submitted this information for the in-depth analysis. The data were collected by the TNO Research Organisation and Dutch Crash Investigation Police departments. TNO is responsible for data coding, data analysis and maintenance of the database. The small number of crashes (30 in all) does not lend itself to reliable analyses, even though interesting indications about the problem of heavy truck crashes have already become visible. It is estimated that a sample of 1,000 crashes is needed to find statistically significant results. The costs are 3,000 Euro per crash and 1,000 Euro per control group location (4).

4. Peculiarities in Hungary regarding the accident statistics

Purely seeing the statistics the same conclusions can be drawn as the leading accident cause is the human factor (more than 90%). If we make a comparison between the years to be analysed the following tendency can be seen. Regarding the different vehicle types (motorcycle, car, lorry) except in the bus traffic an unambiguous decrease can be realised.

Concerning the buses almost 20% decrease could be noticed between 2006 and 2007, but it increased almost reaching the data derived from 2006 in 2008. All these data were introduced from the aspect of the drivers' fault (1, 2, 3).

Regarding the circumstances (Fig. 4) of the accidents the leading causes (20-20%) are still:
- inappropriate speed (vast majority to the road condition)
- denied priority (vast majority despite of road sign)
- non observance of traffic regulations (about 30% denied follow distance, 20% left turning vehicle denied priority of vehicles going ahead or turning right)

About the half of the cases happened in road sections and about the one-third in intersections. Looking at the Hungarian experience the accident types give the following view. 60% of the accidents occurred because of the collision of vehicles in motion. About 10-10% of the accidents happened by collision with parking vehicle or obstructions or skidding, capsizing, leaving line or accident between vehicles and pedestrians (Fig. 5).

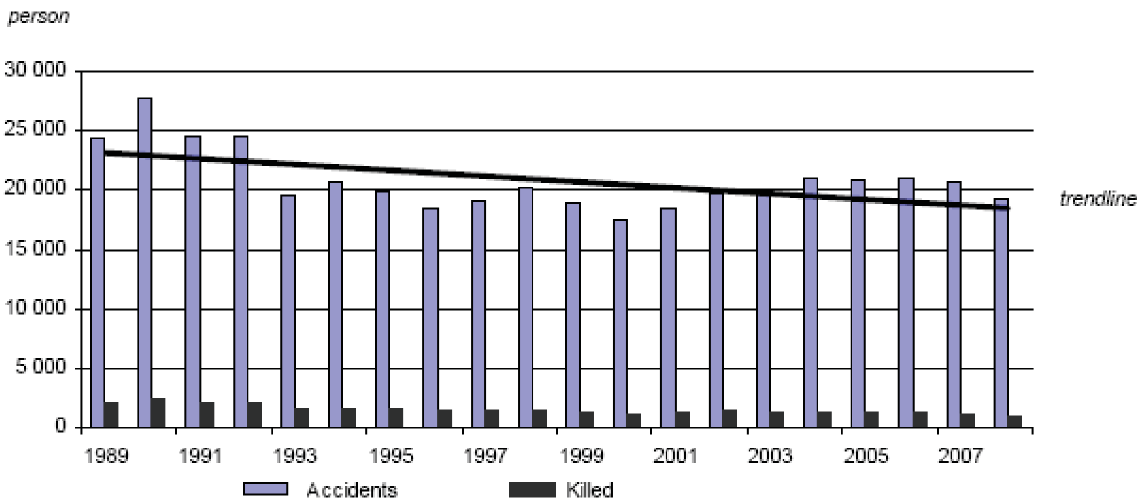
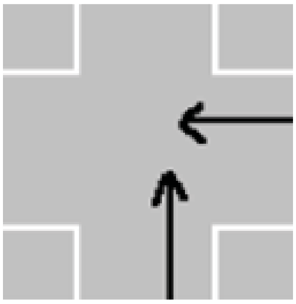
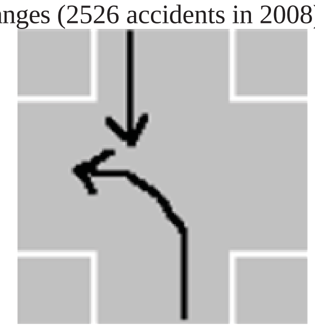


Fig. 3. Diagram of accidents involving personal injury and the number of persons killed (1)

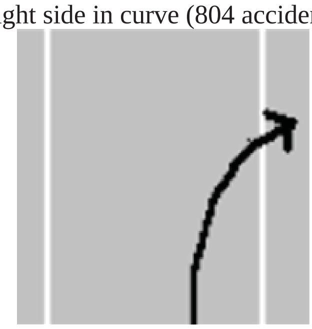


a) Accidents between moving vehicles at interchanges (2526 accidents in 2008)

b) Single vehicle accidents, vehicle is leaving the line on the right side in curve (804 accidents in 2008)



c) Accidents between moving vehicles at interchanges one is turning left (833 accidents in 2008)

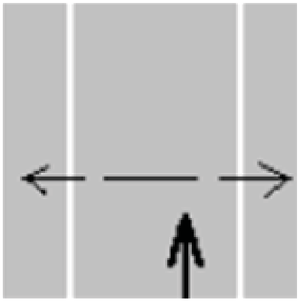


d) Single vehicle accidents, vehicle is leaving the line on the right side (748 accidents in 2008)

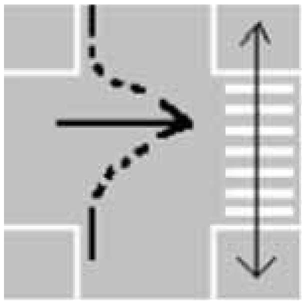
Fig. 4. The most frequent types of vehicle accidents involving personal injury (1)

5. Conclusions

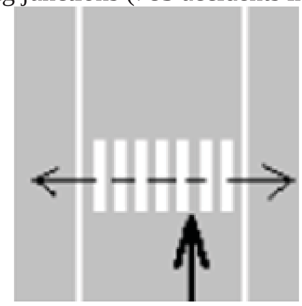
The investigation introduced above aims to perform an analysis that examines the operation of the safety systems of vehicles used in real traffic. In addition to that, a robust remote diagnostic reference system is going to be created that can transfer the data of various vehicle safety systems to a central database where such data are analysed from statistical and telemetric aspects. Such analysis will primarily focus on the type of interventions and their suspected causes. The data collected from the remote diagnostics system will later be integrated with current databases and the correlation analyses of these statistical properties may help forecast accident risk locations/times. The project result may, in the future, help define the directions of legislation and technical research more accurately. Another benefit is that the remote diagnostics system and the developed analytical methodology may help the testing process of newly developed vehicle and traffic safety systems.



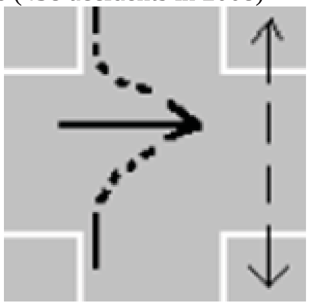
a) Pedestrian accidents outside pedestrian crossings excluding junctions (785 accidents in 2008)



b) Pedestrian accidents at pedestrian crossings at junctions (458 accidents in 2008)



c) Pedestrian accidents at pedestrian crossings excluding junctions (390 accidents in 2008)



d) Pedestrian accidents at junctions outside pedestrian crossings (239 accidents in 2008)

Fig. 5. The most frequent types of pedestrian accidents involving personal injury (1)

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