

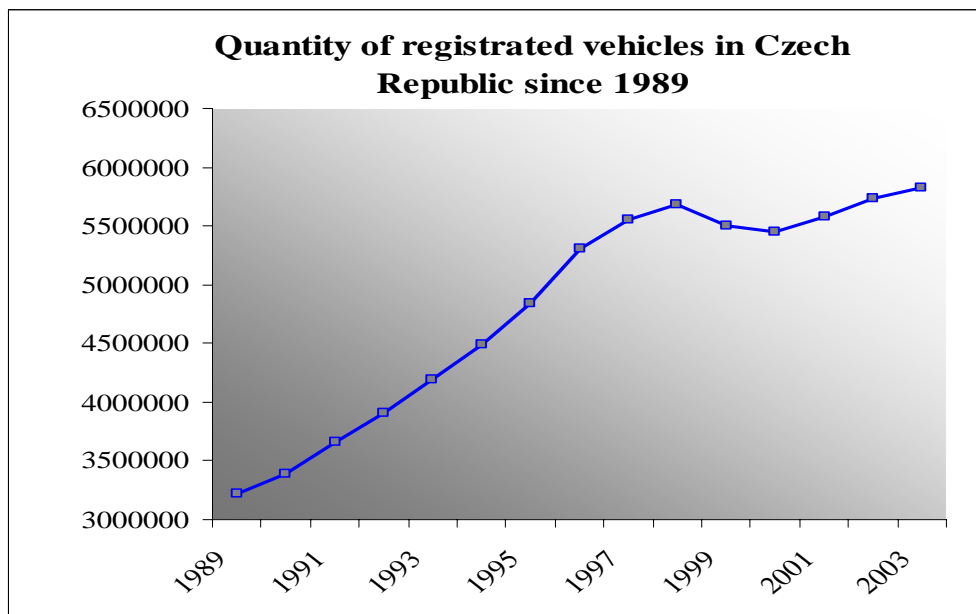
Development and Usage of the Driving Simulators Since 1989

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Abstract: This paper deals with trends of the driving simulators development in the last 15 years and the usage of simulators in practice. The first part of this work emphasizes the necessity of using the driving simulators in the basic and enhancing driving education with respect to the increasing number of registered vehicles and car accidents. Next part deals with the self-development and education capabilities of the driving simulators. Application of driving simulators in the practical and enhancing education (defensive driving course, emergency vehicles drivers training, navigation systems handling, etc.) is described in the last part of this discourse.

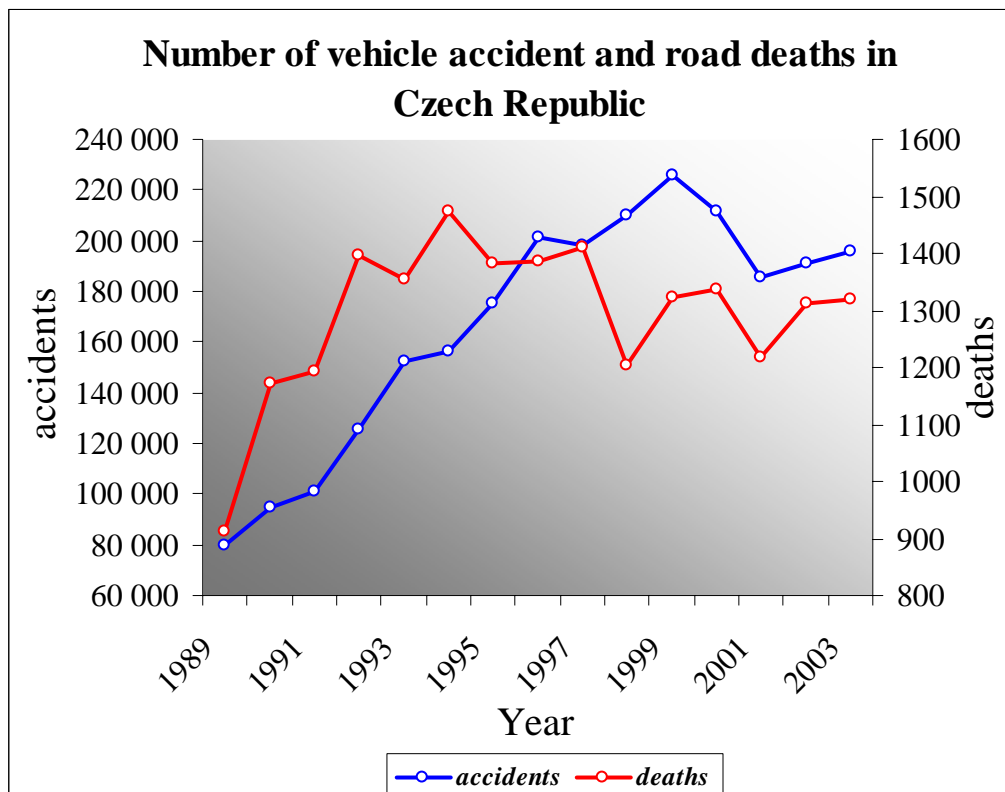
Preface

After the Velvet revolution in 1989 and the sudden change of political regime the living standard of the Czech inhabitants has been rapidly increased. From the traffic point of view this fact was reflected in the increasing of the individual Motor Transport (road transport). Thereby the number of road accidents has increased too and is higher and higher every year. This plight (unpleasant situation) is unfortunately connected with growth of the risk of traffic accident.



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From the 1st diagram is evident that during last 15 years the number of vehicles on Czech roads doubled. On the following diagram we can see development of number of vehicle accidents and road deaths since 1989. As we can see-after the first "boom" both curves became established. Moreover, the "road deaths curve" has descending sequence which is most likely caused by increasing level of passive safety (airbags, seat belts, head rests, crumple zones).



This phenomenon is also supported by the growth of aggressive drivers and people who use their cars influenced by other reasons (compensation of personal failures, discharge of negative energy, stress release, etc.). Last but not least, there is more and more people exhausted and tired by working much more than 8 hrs a day. All those absences in drivers' behavior should be eliminated by professional training e.g. defensive driving or "far-seeing behavior". It would obviously be great if every driver was obliged by attendance in those courses, but -unfortunately- it is not like that. Without the usage of driving simulators is the realization of those courses almost impossible.

New generation car simulators

Driving simulators training is an excellent and necessary component of driving training for all levels of learning. The simulator allows for training in basic or advance levels, including defensive driving principle applications.

Production of simulation systems is based on universal modules / technologies. Such as:

- Efficient simulation software
- High-quality generic or geo-specific databases and models of virtual terrain
- PC based visualization systems (including special sight optics) with all standard and special effects such as NVG and battle simulation
- 6 degrees of freedom on electric motion bases
- Universal consoles for all training stations
- IR camera monitoring system
- Universal electronic system for fast data transfers
- Standard DIS / HLA connection

The actual size and highly detailed driver cabin replica is placed on a motion base. The interior components included rear view mirrors, side view mirrors, force-feedback steering wheel and a vibration motor. Visual system is composed of wide-screen projection (180° x 32°), virtual databases of various environments (training-ground, city, open country, highway etc.), simulation of day, night and weather conditions (rain, fog, snow), including the windshield wiper function. Motion system enables acceleration, shifting, braking, turning, slides and seat vibrations (during driving through terrain disparity).

The equipment of the driver cabin comprises of high-quality stereophonic sound and an active wheel.

The Instructor station controls the functionality of the simulator for simulation configuration. The instructor station helps to set up a training task by using special editor or interactions in training process: control (pause, back, continue, stop), supervision (map display, trainee actions indicators), special functions activation (car failures and accidents simulation).

Training consists of training tasks but also includes the possibility of „free driving“ in the virtual environment. The system can also include a training task planning system as well as an evaluation system with record / playback functions to increase the training efficiency. Training process in general includes: interactive driving skills entry test; basic driving skills

training (starting the engine, gears shifting, driving forward, driving in bends, braking, turning, reverse driving, stopping); various traffic situations (light, normal and dense traffic); action training in dangerous situations and last but not least „defensive driving“ training.

The mathematical apparatus used includes: parametric mathematical models of moving car that enable simulation of various car types; motion system reflecting the car type, weather and other driving conditions; fully functional driver controls and indicators logic; connection to virtual terrain database, including indication of collisions. Automatic traffic generator includes other vehicles movement (e.g. driving through crossing), pedestrian movement and dangerous situations generation.

Driving simulators – practical usage

Practical usage of the driver simulators can be broken into two parts:

1. Driving education – basic (at the driving schools); enhanced (defensive driving course, emergency vehicles drivers training, navigation systems handling, etc.)
2. Research plans (effect of alcohol on the driving performance, impact of fatigue on driving, influence of diseases on driving, etc.)

Driving education

Defensive driving course

Considering solely the human factor, then the driver's safety is determined by:

1. Ability to not incite risky situations by his or her own behavior
2. Ability to protect himself or herself in situations provoked by other road users

For the purpose of the first factor, we can use the term “active safety driving”. The driver gains his driving ability during the training at driving school and then from his or her own experience. “Good driver's” capabilities consist of a complex of abilities, knowledge and skills, which allows the driver to drive from point A to point B with a high probability of not causing an accident.

For the purpose of the second factor we can use the term “defensive driving”. The driver knows the methods that protect him against risky behavior of other road users. These skills will be obtained in the defensive driving course. The result is safe driving, even if the environment is dangerous. We can call driver like this a “defensive driver”. This driver can drive from point A to point B with high probability of not being involved in an accident even if he or she faces mistakes of other road users.

Defensive driving courses are held in the Traffic Academy of Bohemia. First, we let the driver go through the training focused on his or her effective behavior in critical situations.

Later on, we let the driver go through the training in a defensive driving course. This one-day course consists of one theoretical and two practical parts. In the theoretical part we lecture on psychological aspects of defensive driving. The practical training knowledge of defensive driving takes place in the first practical part. This training is carried out in a real traffic. For the second practical part, the driving simulator is used. The simulator is packed with a collection of exercises related to solving risky situations. The driver is trained, how to recognize dynamens (hidden dangerous). Using a simulator allows training, which wouldn't be possible in a real traffic, because there is no possibility to manipulate the other road users, no chance to repeat situations and moreover training like this would be very dangerous.

We have to distinguish risky and critical situations in both courses. While the first course is focused on critical situations, the second one is focused on risky situations. Critical situation can precede an accident and risky situation can precede a crisis. Driver can get into a risky situation even if he or she drives according to the traffic rules. If the driver doesn't want to get into a critical situation he or she has to be able to recognize a risky situation and keep out of it.

If the training in driving school is appropriate, the driver will act in critical situations with 50% efficiency. The efficiency can increase up to 90% after completing the course focused on effective acting in critical situations. However, the driver should not even get into any critical situation after completing the defensive driving course and accepting the philosophy of a defensive strategy.

Emergency vehicles drivers training

According to the law in the Czech Republic should emergency vehicles drivers yearly go through the rehearsal theoretical training. In the Traffic Academy of Bohemia takes place additionally practical part of this training. There is a possibility to carry out this practical part in the real traffic, but it brings a risks and limits. Another possibility is driving simulator. There is chance to create sample situations or encounters. There are two alternatives in using driving simulator in this training:

1. Using single driving simulator
2. Two interconnected simulators or one simulator connected to instructor's workplace

Single simulator can be used e.g. for ambulance drivers training. The other road users respect the ambulance cars because the urgency of saving human being is well-known. Their behavior

is almost passive and let the ambulance go. The other road users' behavior can be preset or casual.

The situation is a bit different in case of other priority vehicles, e.g. power engineering as other drivers usually don't respect them. The training of the police vehicles drivers is yet absolutely different. There is a possibility that a pursued vehicle can attack the police car. To simulate these situations, we can use an interconnection of two driving simulators (one of them managed by the instructor) but this option is very expensive. Another possibility is to connect the instructor's workplace to a single driving simulator. The instructor can actively participate in the training (representing an aggressor pursued by the police). This option is much cheaper because the instructor only needs to enter the virtual area and actively participate in, not to live through.

Navigation system handling

There is a possibility of learning how to handle a navigation system during car driving but it really isn't safe. Operating a navigation system is more attention-consuming than, for example, handling a mobile phone. There is a high level of distraction even if the driver knows how to handle navigation systems the more so when learns its functions. Therefore it is very reasonable to pass navigation system training on a driving simulator in order to maintain traffic safety.

Research plans

The "Effect of Diabetes Mellitus on driving performance and relation to fatigue and alcohol effect" research was carried out in the Traffic Academy of Bohemia in co-operation with Transport Research centre. This study was held in the framework of the IMMORTAL project focused to illnesses and diseases impact to driver performance and his/her safe behaviour on the road. An E-DAS driving simulator was used for the experiment.

The research investigated the effects of Diabetes Mellitus type 1 to driver performance and his/her ability to drive safely. Laboratory psychological assessment was used to evaluation of basic mental and personal capabilities which are known as risky aspects in the context of traffic human factor. The driver simulator test was used for evaluation of the driver's behaviour in various traffic conditions and situations. The same simulator test was applied to assess the effect of alcohol on driver's behaviour.

The driver simulator test was prepared and developed in close co-operation with diabetes experts and driving school instructors. It constituted the basic driver tasks, risky

traffic situations, various traffic and climatic conditions and also simulated behaviour of other drivers. Three groups of drivers were involved in this test – diabetic drivers, control group of healthy and alcohol non impaired drivers and group of drivers affected by alcohol.

Test Program

Special SW in the simulator provided for creation of a series of tasks to be completed by all participants of the test (“probants”). The point was to prove the ability of avoiding risky situations (a risk situation is one that may develop into a critical situation potentially leading to a traffic accident), to react properly in critical situations, etc. Individual test tasks were installed in different databases (small town, large town, country road, expressway) and various climatic and visibility conditions (daytime, nighttime, fog, rain, snowing) were applied. The program simulated the behavior of other road users in virtual traffic, independently or depending on each probant’s conduct. The probant came upon certain situations independently by following instructions from the examiner concerning the direction to take at each intersection, or the situation was generated by a quasi autopilot that passed control onto the driver at a certain moment, so that he continued independently. Some of the tasks were repeated (to see whether the probant has learned how to react during the previous round), other tasks turned up just once, because the first passing made it evident what the situation is about, so that another round would have been taken with awareness of the principle of that task.

Preparation of the series of tasks was based, among other things, on experiences collected with continuous training of drivers, especially courses of defensive driving. Before starting the actual test with the experimental DM group, the series of tasks were checked on a control sample of 5 drivers who didn’t have DM.

Indicators Followed During Simulated Test:

Psychological:

- General driving skills
- The test establishes reference driving skills of the probant, used as a base for the assessment of overall results of the test
- Ability to avoid risky situations
- Ability to act in regular risky and critical situations

- Behavior at the end of attacks (offences) of other traffic participants: Correct reaction is evaluated, as well as subjective psychological disposition at the end of the series (anxiety, etc.).
- Performance stability: It is evaluated whether repetitive tasks lead to a slowdown of ability to react and generally evident fatigue
- Pathological elements of driving conduct: e.g., suicidal tendency, especially when it is apparently impossible to solve a difficult situation, “giving up”, and aggressive or asocial (off-standard) behavior in general.

Physiological

- Pulse frequency: The probant’s vegetative symptoms – pulse –during the test using an optical sensor attached to the probant’s ear lobe.
- Disposition to pseudokinetosis: Observation of basic symptoms, or onset of interruption or temporary interruption of the test.

Test description:

All probants were subjected to an identical test, identical methods of evaluation were used, and the same indicators were followed. The test on the simulator lasts 60 minutes; thereof the first 5 minutes involve familiarization with the test, followed by 10 minutes of independent driving with the simulator in a database environment, determining the direction of driving, and learning how to handle the behavior of the simulator. During this time, the probant was carefully followed for any symptoms of pseudokinetosis. During the following 40 minutes, the actual test took place, using a series of tasks described above. The last 5 minutes were dedicated to a final interview with the probant.

The control group drivers were not informed about the project on purpose, for maximum elimination of potential negative effects.

Behaviour and conduct of the driver in the course of the individual tasks were evaluated by the control unit of the simulator on the basis of predefined criteria (measurable), and subjectively by the examiner. The evaluation also included record of heartbeat of the tested driver throughout the test. An optical sensor took the heartbeat from the ear of the driver.

Main results and findings of this study:

There are no reasons for discrimination of diabetes drivers if they control self-monitoring operations, keep regime of diet, regular medicine checking and fundamentals of safety driver behaviour.

There are some restrictions on professional drivers concerning diabetes mellitus type 1. They cannot satisfy all the conditions because of their dependence on work and employer demands. The risk of accidents with serious damages caused by them is so high.

All of the indicators followed show evident decline of driving ability by about 35% for the probants under influence of alcohol. Their driving technique was unrefined and they were rough to the vehicle. These probants had a higher disposition towards confrontational traffic behavior (dynamens) and showed signs of distraction. Their conduct in critical situations revealed inappropriate reactions, aggression, and a tendency to make excuses or jokes for their disabilities based on objective causes. Early onset of fatigue was evident. Tendency to pseudokinetosis was nearly none.

Conclusion

The aim of usage of driving simulators in driving schools and research projects is not based on saving money for petrol by far. The main reason for the increasing popularity of driving simulators is their high flexibility to our demands. Defensive driving course, emergency vehicles drivers training (Ambulance cars, Police vehicles, etc.) is not possible to realize in real traffic because of the safety of other participants and inability of surrounding to accommodate to our actual demands.

If we focus on research intentions (alcohol influence on driver, somatic diseases, vigilance monitoring, etc.) we can not make those researches without the Driving simulator as well. In case of GPS handling courses (navigation systems) it is easier to imagine those in real traffic but anyway-the road safety is obviously not increased by that. (Because attention of driver is focused on "how to use navigation" instead of "how to drive".)

Another argument for usage of driving simulators is the fact that their construction and equipment is more and more like in real car. Just as the steering system. Whereas the price of driving simulators has decreased, the level of their reality as the "copy" of real cars has increased.

References

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