SIMTEB

Simulator-based Training for European Bus Drivers

Education and Culture DG

Lifelong Learning Programme

Project SIMTEB

Simulator-based training for European bus drivers

Transfer and implementation of an innovative training concept for drivers and trainers in initial and continuing education organizations in the

Status of Simulator Training for Professional Drivers in Europe

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Dortmund, October 2012

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Preliminary remarks

This discussion paper summarises the main results from the concluded STB project (2011), from the on-going SIMTEB project (2011) and from extensive research on the Internet reporting the status of simulator training for professional drivers in Europe. The report is intended for later use in the SIMTEB project.

The discussion paper contains mainly critical arguments, which rather speak against more widespread deployment of simulator technology for training professional drivers in the foreseeable future. This is particularly attributable to the difficult legal constraints which, in the wake of the first evaluation of the implementation of EU Directive 2003/59/EC by the EU Commission (2012), predominantly determine the current status quo. Questions concerning cost efficiency and the recruitment and training of instructors for simulators likewise still have to be resolved.

However, the first signs of new strategies for the introduction of simulators in training centres and transport undertakings can be recognised. It is certainly interesting that simulators in the class below € 100,000 are now accepted as certified, top-of-the-range simulators in some EU countries. On the one hand, this throws up questions of evaluation, particularly concerning simulators fitted with a lower level of training equipment. On the other hand, this acceptance could possibly provide impetus for the development of successful business models.

A major question still to be answered is whether simulator technology can succeed in making the breakthrough, leading to more widespread deployment on the expanding market for initial and advanced training of professional drivers. Climate change and the need for greater professionalism among bus and truck drivers would seem to speak for this. The SIMTEB project could also possibly contribute towards these developments. First a few remarks on the structure and content of this discussion paper.

Chapter 1 is based on a review of the literature prepared by Lisa Dorn and Robert Edmunds, who are partners in the project, which looks at studies on the efficiency of driving simulators. In the opinion of the authors, the studies demonstrate, to a limited extent, that skills acquired on a simulator can be transferred to daily driving practice. Dorn and Edwards nevertheless believe that a series of open questions must be clarified before a positive judgement can be passed on the effectiveness of driving simulators.

Chapter 2 describes the regulations in EU Directive 2003/59/EC specific to simulators and their implementation in the legal norms of individual EU countries. The majority of regulations established do little to promote training on simulators (this primarily concerns the vague regulation of periodic training). However, regulations have been passed in some EU countries (Denmark, France, Netherlands), which really could be regarded as useful in promoting simulator training. Simulator training has nevertheless not really been able to gain a foothold to date, not even in these countries.

Chapter 3 investigates the conditions under which simulator training is performed in practice. The reasons why simulator training has failed to become anchored in transport undertakings are discussed, whilst approaches for designing a European framework concept for simulator training are reviewed in the qualification courses offered by the handful of simulator operators.

Chapter 4 summarises the generally rather restrictive tendencies for introducing simulator training in the transport sector and for training bus drivers. This review outlines a number of social and commercial prerequisites identified as important for the sustainable development of simulator training. Apart from changes in the framework social conditions, active strategies are also discussed, with which the different actors involved in the introduction of simulator training could promote this form of training.

1. Studies on the effectiveness of driving simulators

The following chapter is based on a review of the literature by Lisa Dorn and Robert Edmunds (2012) concerning the effectiveness of simulator-supported training for drivers (Dorn and Edmunds 2012). The authors are members of the Driving Research Group at Cranfield University in Great Britain and are partners in the SIMTEB project. They are responsible for evaluating the training modules to be developed during the project.

This chapter presents the main thrust of this overview study. With the exception of specifically marked references, all literature references in this chapter are drawn from sources quoted in the study made by Dorn and Edmunds.

The study of the literature focuses on the question of the extent to which the skills acquired during training on a driving simulator can really be transferred to daily driving practice (see Dorn and Edmunds, P. 1). The authors point out that a driver's learning success can be demonstrated not only on a simulator, but also in real traffic conditions. The authors believe that such an investigation is required because, although there is substantial literature on the influence of specific forms of simulator training or training programmes on the driving conduct of drivers on a simulator, studies which provide evidence that the skills acquired on a simulator can be transferred to real traffic situations are few and far between (see Dorn and Edmunds).

Dorn and Edmunds see the main reason for these problems in the difficulty in finding a comparative group trained in the conventional manner in real vehicles. The alternative would be to examine the driving abilities of a group of guinea pigs before and after training on a simulator in their daily lives as professional drivers. The authors regard this alternative as fraught with difficulties because the factors in real traffic at play on a driver's behaviour could influence the comparability of the results obtained before and after training in a way that would be difficult to control (ebenda).

According to Dorn and Edmunds (2012, P. 2), the results of validation studies, which demonstrate the success of training in aircraft simulators, cannot be used for assessing ground-based simulators.

Against the backdrop of the present situation, in which there is little empirical evidence for the efficiency of simulator training, Dorn and Edmunds provide an overview of the

few studies containing results that could suggest a positive evaluation of simulator training.

Selected investigations from the overview study made by Dorn and Edmunds are presented below.

1.1 Simulator training for drivers in emergency services

Dorn and Edmunds (2012, P. 6) initially present a study by Turpin (2006) on this subject. This study examined the effect that the introduction of simulator training had on the frequency and severity of errors made by drivers in the police, fire and ambulance services. To this end, he compared records of the (conventional) training in the past with performance levels after simulator training had been introduced. Before the simulator programme was launched, the majority of drivers in police, fire or ambulance services undergoing training went directly onto the test circuit in a real vehicle after being taught theory in the classroom. On average, 25 errors were made by each of the learner drivers during this course, of which four errors occurred in particularly critical situations. This procedure was then changed, and the learner drivers first moved to simulator training after instruction in the classroom, and only then onto the test circuit. This time an average of only 12 errors per learner driver was recorded, the number of errors in particularly critical situations even fell to below one. This means that the errors in particularly critical situations were reduced by 75 %. Such a reduction of errors in situations particularly fraught with risks would suggest that the skills acquired in a simulator can be transferred into driving practice.

Dorn and Edmunds (2012, P. 7) furthermore present the preliminary findings of an investigation into the driving abilities of Bavarian police trainees in emergencies (see Neukum et al 2003). The police trainees are trained in a high fidelity simulator. Simulator training is part of a wide-ranging training programme run by the Bavarian police force. The study – which is still on-going at the date of publication - aims to establish whether the skills acquired on a simulator can be transferred to real situations on the roads. On the basis of assessments made by the driving instructors, those responsible for the simulator-supported training programme come to the general conclusion that simulator-

based training is an effective method of improving the driving skills of police officers during emergency runs and rescue operations.

1.2 Simulator training for truck drivers

Dorn and Edmunds examine in some detail the question of whether the skills learned by truck drivers in simulator training can be transferred to real traffic situations. The main basis for this is the research performed by the Transport Research Laboratory (TRL) in Great Britain. TRL has operated a full-motion-base truck simulator (called TruckSim) since October 2003.

We now want to look more closely at the project activities of TRL depicted by Dorn and Edmunds in their study of the literature:

600 drivers took part in a training and validation study between 2003 and 2004 (Dorn and Edmunds 2012, P. 9 f.). This study focused on the quantitative analysis of the efficiency and acceptance of specific simulator exercises (Parks and Rau 2004). Drivers did change to real traffic conditions in the course of this study. The study was able to identify training elements that could be effectively taught by simulator training. Such training elements were primarily attributable to a tactical level of driving (e.g. consumption of fuel, driving techniques in poor weather, reaction in emergencies), whilst exercises with greater emphasis on the operative control level (e.g. manoeuvring a truck at low speed on a car park), proved to be less beneficial compared to conventional training in a real vehicle.

A follow-up study (Dorn and Edmunds 2012, P. 10) investigated whether the skills acquired on an Eco-driving training course in the TruckSim simulator could be transferred to driving behaviour in real traffic (Reed et al 2012). To this end, 60 truck drivers were trained in the simulator three times over a six month period to encourage a driving style aimed at saving fuel. An automatic evaluation system informed the drivers of their performance. The behaviour of the drivers in real traffic was recorded during this phase with regard to fuel-saving improvements in their driving style. In order to eliminate seasonal influences on the efficient use of fuel, the driving behaviour of a control group of 60 drivers, who received no training during this period, was also recorded. The results of the study show that the group of drivers trained in the simulator increasing improved

their driving style vis-à-vis saving fuel compared to the control group. A 16 per cent improvement in fuel consumption in real traffic was thus achieved in the third training unit. The data measured by the simulator appear to suggest that this improvement was achieved by running the engine in a lower RPM range.

The first British undertaking to use TruckSim for training its drivers under commercial aspects was Allied Bakeries (AB) (Dorn and Edmunds 2012, P. 10). The results of an Eco-training course on a simulator found an average fuel saving of 7.3 % in practical application. The greatest improvements were achieved by drivers on mixed routes, whilst the least improvements were found with drivers whose routes were in urban areas. The fuel savings observed – superimposed onto the annual consumption of fuel – reap not only considerable cost benefits, but also reduce CO2 emissions by more than 250 tons. In summary, Reed et al (2012) estimate that the fuel savings achieved ought to lead to a return on investment for training drivers in a little more than four months.

Uhr et al (2003) made a comparison (Dorn and Edmunds 2012, P. 10 f.) between a driving school truck and an advanced driving simulator. In this study, 50 experienced truck drivers were taught to park a truck and trailer backwards from one side of the road to the other. The drivers were divided into two groups. One group was given initial training in a real truck, the other group was trained in a simulator. The two groups were then asked to perform the same manoeuvre 3 times in a real truck. The study found that both positive and negative elements learned on the simulator were transferred into practical application in a real truck. Both groups had similar success in performing the manoeuvres. This would suggest that simulator training is equivalent to training in a real vehicle when it comes to putting the skills acquired there into practical use. However, the group trained in the simulator required more time for the exercise and made considerably more steerage corrections in the process. The authors suspect that this was attributable to the very high sensitivity of the steering system in the simulator programme. The fact is that the simulator was much more difficult to steer, greater precision was required and there was less tolerance of errors compared to the real truck used for training purposes. On the whole, this means that abilities acquired on a simulator can be transferred to real driving on the roads; however, undesirable habits can also be transferred if the simulator differs from the real vehicle in significant aspects.

Kelly (2006) reported in a trade journal for private sector transport companies on the evaluation of simulator-supported training at Schneider National, one of the leading freight carriers in North America (Dorn and Edmunds 2012, P. 11.). Schneider National intended to install 50 simulators throughout America for training its 16,000 drivers and began to evaluate the effects of simulator training in an ambitious pilot programme in 2004. The study looked at a group of 1,200 new drivers, who took part in a programme run by the undertaking to obtain a CDL (Commercial Driver's License). This group was divided up into drivers who were trained in the traditional way, and drivers who were trained with the support of a simulator (Mark III full-motion simulator from MPRI, a division of L3 Communications). With regard to the success of the training, small - although measureable - improvements were established between the two groups studied. 85 % of the drivers in the simulator group achieved the training goal compared to 77 % in the control group. Accidents (at a value of over US $ 15,000) were 30 % lower for the drivers trained in the simulator compared to the control group. These results are statistically significant.

The SIMULATOR VALIDATION STUDY performed by the Center for Truck and Bus Safety at the Virginia Tech Transportation Institute (Morgan et al 2011) investigated the effectiveness of using a simulator for training and for examining learner drivers during their preparations for the CDL test for heavy goods vehicles. The following four training groups were formed from a group totalling 107 people:

- A conventionally trained group, who received 104 hours theory and 46 hours practical lessons (100 % in an exercise vehicle)
- A conventionally trained group, who received 104 hours theory and 46 hours practical lessons (*60 % in a simulator* and 40 % in an exercise vehicle)
- An informally trained group (who received training from friends or family members)
- A conventionally trained group, who underwent a shorter period of training

A comparison of the results obtained using these four different methods produced the statistically significant upshot that no difference could be established between the group trained solely in a real vehicle and the group trained both on a simulator and in a real vehicle. The authors of the study claim this as evidence that training on a simulator is a valid method for the practical training of learner drivers (Morgan et al. 2011, P. xxi). A follow-up study was performed 4 months later involving 22 of the former trainees who

had found jobs as truck drivers during the economic downturn, but this could not establish any differences in their performance, safe driving behaviour or in the traffic offences recorded by the supervisory bodies. The small size of the sample group, the too short period of time and the low occurrence of violations (ten) meant that the number of entries was too low for any meaningful statistical analysis to be drawn (this summary of the SIMULATOR VALIDATION STUDY was added by the author).

1.3 Influence of simulator training on the rate of accidents

In their research of the literature, Dorn and Edmunds (2012, P. 13ff.) likewise believe that the jury is still out on the question of whether simulator-supported driver training helps to reduce the rate of accidents. Although this question has been tackled by numerous studies, Dorn and Edmunds nevertheless point out that the majority of these studies refer to earlier work undertaken by Edwards, Hahn and Fleischmann (1977). In addition, there are reasons to believe that some of these studies indicate that there is a general problem with validating the influence that simulator programmes have in the reduction of accidents. They claim that there are a large number of potential influencing factors at work here. Insofar as statistically significant correlations are found between simulator training and the occurrence of accidents, these are deemed to be often coincidental and do not provide any meaningful evidence.

1.4 Simulator training for bus drivers

A question of particular interest to the SIMTEB project is the extent to which results relevant to an evaluation of bus driving simulators are available. This is answered mainly in the negative by Dorn and Edmunds.

However, despite the apparent lack of literature dealing with bus driving simulators and the transfer of the skills learned on them into practice, the authors (mistakenly) assume that such training aids seem to be growing in popularity. The authors base this claim on statements on the operation of bus driving simulators released by the large transport

undertakings Arriva and First in Britain, STC in Finland and the Metropolitan Transportation Authority (MTA) in New York (Dorn and Edmunds 2012, P. 12).[1]

Little research work has been undertaken into the training of bus drivers on simulators (see Dorn and Edmunds 2012, P. 12). An exception to this is a simulator developed for the European bus and rail operator Arriva by Cranfield University (Muncie and Dorn 2003a, 2003b). The Arriva Bus Simulator (ABS) was based on scenarios produced from analysing 20,000 video recordings of real-life traffic situations. This process increased the validity of the Arriva Bus Simulator and led to a training system closely oriented to realistic traffic situations. The simulator's face validity was also judged in an accordingly positive light. The drivers involved in the pilot project reported that they drove the simulator like a real bus after a time, despite the discrepancies between the Arriva Simulator and a real bus. Muncie and Dorn took this to be evidence of the behavioural validity of the ABS.

Dorn and Edmunds nevertheless reject the claim that simulator training is a suitable method to improve training for professional drivers on the basis of simulating realistic traffic situations within the framework of the training scenarios purported here. They argue that hardly any research work has been published on the use of bus simulators that provides evidence for the effectiveness of simulator training. According to Dorn and Edmunds, the literature cited by Lang et al (2012) on the efficiency of simulator training in Eco-driving courses for truck drivers (Parkes 2004; Parkes and Rau 2004) likewise does not provide sufficient evidence for the efficiency of simulator training. This is because the successes of simulator training transposed onto real traffic conditions – compared to conventional training – are still to be demonstrated. That is why Dorn and Edmunds see the introduction of simulators as only being a partly sensible measure for training learner drivers and for periodic training of more experienced drivers.

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[1] This assumption of the increasing popularity of bus driving simulators derived from the existence of these 4 simulators is nevertheless contradicted by the fact that the STC company went bankrupt in 2009 (see Publications of the Ownership Steering Department 2010, P. 79), whilst the First company has significantly reduced bus driver training on simulators in recent years (Minutes STB Meeting 2010). It seems that only one new mid-range simulator (see further below for the term "mid-range simulator) for training bus drivers has been approved in Europe in the last few years and, according to the research carried out by the STB project, there are only 6 or 7 driving simulators of this class for training bus drivers in Europe (there are only informal reports of the decommissioning of the ARRIVA simulator in the UK to date). This would seem to justify the impression that the present legal framework hardly provides impetus for the introduction of driving simulators (see Schröder and Grüneberg. 2011, P. 4).

Apart from the fact that the efficiency of simulator training for bus drivers still has to be evaluated under practical conditions, there are further challenges facing simulator research.

Lang et al (2012) found that

- potential simulator operators are often uncertain about the specific opportunities offered by simulator training and the benefits this could bring for the organisation, the workforce, the environment and the selection of suitable equipment
- potential users frequently lack the know-how and an appropriate education to adapt the existing didactic concepts to the needs of simulator training courses and to integrate these into the training system
- changes in the role of driving instructors are nor adequately taken into account in the work with the simulator technology and the associated requirements on “training the instructor” are often overlooked or are ill defined

1.5 Summary

In their concluding summary, Dorn and Edmunds (2012, P. 15) see some limited evidence that skills acquired on a driving simulator can be transferred to real driving behaviour on the roads. However, they believe that extensive research is still required to establish the nature of training courses suitable for simulator-supported programmes, in order to understand which skills can be transferred into practice and under what circumstances. There seems to be very little evidence of the effectiveness of truck simulators. Put into a sober perspective, Dorn and Edmunds believe that there is only one academic study into such simulators that provides evidence of a positive transfer of skills learned on a simulator to real-life traffic conditions, plus an industry report that might suggest that accidents and fluctuations were able to be reduced. Dorn and Edmunds argue that although there seem to be positive aspects in deploying simulators for training drivers, these results are few in comparison to aviation. The field of driving simulators is therefore open to research in future. An obvious linkage between simulator training and the occurrence of accidents has not been able to be established to date.

In conclusion, it should be remarked that the arguments put forward by Dorn and Edmunds (admittedly only based on patchy empirical evidence) concerning the effectiveness of transferring skills acquired on a simulator to practical conditions, nevertheless underline the importance of testing the training modules to be developed in the course of the SIMTEB project. Above all, this means that the test results must be validated by means of empirically sound “before & after” investigations applying methodological recording standards.

If such recording conditions can be realised, the SIMTEB project has the chance to build upon the status of research into the effects of simulator training in the transfer to practice and – if the effectiveness of simulator training can be demonstrated – to raise levels of acceptance for these new training methods amongst potential users.

2. Legal framework for simulator training

This chapter describes the legal framework, starting with the enforcement of EU Directive 2003/59/EC nine years ago, which first mentioned the deployment of simulators for training professional drivers.

EU Directive 2003/59/EC was aimed at educating drivers engaged in the carriage of goods or passengers. The directive expounded upon the criteria for obtaining or holding driving licenses of category C (goods traffic) and D (passenger traffic), thereby distinguishing between “initial qualification” and “periodic training”.

This was the first piece of European legislation that laid down framework conditions for deploying simulators for training professional drivers throughout the European Union (plus Norway and Switzerland, which also took these regulations on board).

The legislation for initial qualification and periodic training allows a “top-of-the-range simulator” to be deployed for parts of practical training that had formerly been conducted only in buses or trucks.

Directive 2003/59/EC does not expand upon the term “top-of-the-range”. The directive nevertheless gives an idea of what is to be expected from a top-of-the-range simulator with regard to the requirements placed upon it for initial qualification. Section 2, Article 3 (1)(a) of the directive states:

> **“**The practical test may be supplemented by a third test taking place on a special terrain or on a top-of-the-range simulator so as to assess training in rational driving based on safety regulations, in particular with regard to vehicle handling in different road conditions and the way they change with different atmospheric conditions and the time of day or night.”

From this description, Bekiaris (2009 et al P.29) derives the following requirements on a top-of-the-range simulator:

- Simulation of different weather conditions
- Simulation of different traffic situations
- Effectiveness of driving
- Safety regulations

Regardless of how such derivations from directive 2003/59/EC are interpreted, they hardly form a sensible basis for determining criteria to judge the performance of simulators for the individual EU countries and/or for the institutions responsible for accrediting such simulators. This situation means that simulator manufacturers have been faced with the problem of not being able to develop their devices conform to uniform specifications.

In what follows, the options for training drivers on simulators, as laid down by the directive, are discussed both at European and domestic level.

2.1 Simulator-specific regulations in EU Directive 2003/59/EC

The directive stipulates that drivers must demonstrate their professional competence by fulfilling the requirements of initial qualification and periodic training. The objectives are to raise traffic safety standards, reduce fuel consumption and generate lower wear and tear on buses and HGVs.

The following regulations apply to practical training courses, which include simulator-supported training:

2.1.1 Limits of time on simulator training

ANNEX I, Section 2: Compulsory initial qualification provided for in Article 3 (1)(a) of the directive formulates the option of undergoing a part of the initial qualification in a simulator as follows:

"Each trainee must drive for at least 10 hours individually in a vehicle of the category concerned…
Each driver may drive for a maximum of eight hours of the 20 hours of individual driving on special terrain or on a top-of-the-range simulator…"

Insofar as "accelerated initial qualification" (*ANNEX I, Section 3 provided for in Article 3 (2*)) is foreseen as an alternative to or as the sole form of initial qualification in an EU state, the percentage of practical driving training - for which a simulator could also be deployed - would be reduced to 4 hours (of a total of 10 hours training in a vehicle).

This regulation in the EU directive means that 40 % of the initial, practical training could be held in a simulator.

The duration of periodic training is regulated in *Section 4 provided for Article 3(1)(b)*:

"The duration of compulsory periodic training courses must be of 35 hours every five years, given in periods of at least seven hours. Such periodic training may be provided, in part, on top-of-the-range simulators."

Although these formulations are vague, compulsory periodic training courses on a simulator are nevertheless feasible. There is no obligation to perform practical training courses here – contrary to the initial qualification discussed above.

It may seem to some that the directive created an apparently giant market for the deployment of simulators to train professional drivers. Apart from the one-off initial qualification to be undergone by every new professional driver, all EU drivers should participate in periodic training courses comprising 35 hours every five years (since 10th September 2008 for bus drivers and 10th September 2009 for HGV drivers). According to the European Commission (2012, P. 5), this concerns "the drivers of some 6 million vehicles in Europe"**.** Yet compared to initial qualification, it is not clear what form of periodic training professional drivers should undertake because there is no obligation to hold practical training courses for periodic training.

2.1.2 Designing the content of simulator training

The subjects of relevance to training on a simulator are laid down in a "List of subjects". This list is part of the "Minimum qualification and training requirements" defined in Annex I, Section 1 of EU Directive 2003/59/EC. The knowledge and skills listed therein must be taken into account by the member states of the EU when establishing the driver's initial

qualification and periodic training. The training programme and the teaching materials and methods deployed must be approved by the responsible national institutions.

The "**List of subjects"** is broken down into three main groups:

"1. Advanced training in rational driving based on safety regulations"

"2. Application of regulations"

"3. Health, road and environmental safety, service, logistics"

Arguments for training on a simulator can primarily be seen in the following objectives grouped under "Advanced training in rational driving...":

1.3. "Ability to optimise fuel consumption".
(this by applying the know-how as regards points 1.1+1.2)

1.5 "Ability to ensure passenger comfort and safety"
"Adjusting longitudinal and sideways movements, road sharing, position on the road, smooth braking, overhang operations, using specific infrastructures (public areas, dedicated lanes), managing conflicts between safe driving and other roles as a driver, interacting with passengers, particularities of certain groups of passengers (disabled persons, children)."

1.6 "Ability to load the vehicle with due regard for safety rules and proper vehicle use"
"Forces affecting vehicles in motion, use of gearbox-ratios to vehicle load and road profile, calculation of payload of vehicle or assembly, load distribution, consequences of overloading the axle, vehicle stability and centre of gravity."

The list of subjects in section 1, especially those grouped under "Ability to optimise fuel consumption", provide some incentive to develop training programmes for courses on a simulator.

Simulators can be deployed for initial and advanced training, providing the competent authorities of the member state concerned regard the "top-of-the-range" criterion as being fulfilled.

2.2 Implementation of the EU directive

By their very nature, the provisions of EU directives offer some room for interpretation when it comes to their implementation in 27 different EU countries. This sub-section is concerned with general trends, yet also with the differences in legal prerequisites for simulator training, as have arisen in the course of implementing EU Directive 2003/59/EC into national law.

2.2.1 The term “top-of-the-range simulator”

As this term is not defined in more detail, numerous member states apparently assess the accreditation capability of a simulator by applying the criteria “fully moving” and “cab type”.[2] Despite the evidently increasing lack of interest among national and transnational institutions, committees and work circles in getting to grips with the “question of definition”, the rather vague term “top-of-the-range simulator” can also be interpreted as a product of developments in information technology. Hardware, in particular, is subject to sea changes and models can well become obsolete after just a few years. As an example, the authors of the Simulator Validation Study II performed in the USA (Morgan et al 2011, P. 8f.) were concerned that a 3-level classification system used for the last 10 years (Level 1: open-loop video, Level 2: low-end simulators, Level 3: mid-range simulators, see Brock et al 2001) had changed noticeably. Developments in information technology meant that mid-range simulators had been more or less replaced the low-end simulator group (see Morgan et al 2011, P. 8f.).

The driving simulators accredited in Europe for training bus drivers are generally built into the cabin of an original vehicle. They thus have an original dashboard, a motion system with three degrees of freedom, a large-area projection screen to depict computer-generated traffic situations and they allow the instructors to develop scenarios for initial and advanced training. Such features are offered by mid-range simulators (these bridge the gap between simple, low-cost devices and complex, high-end research simulators), which have been the state-of-the-art for training bus drivers in Europe to date (see Appendix 1).

The range of simulators capable of being accredited has nevertheless grown in recent years. Although the technical specifications of such systems may not reach those of mid-range simulators in every aspect (e.g. cabin not enclosed, no original dashboard, but with a motion system with 3 F), they still cannot be categorised as low-cost simulators (Piorunkiewicz 2011).

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[2] “The Directive does not define what this term means, though the Agencies understand some other national authorities interpret it to mean a ‘cab type’ fully moving simulator.” (s. Explanatory Memorandum, Fn 26)

2.2.2 Results of the CIECA poll

What follows depicts the results of a poll carried out by the International Commission for Driver Testing CIECA (2010) in the 27 EU countries, plus Norway and Switzerland, concerning the implementation of EU Directive 2003/59/EC with regard to training on simulators:

- For initial qualification, most countries (with the exception of Malta, Austria, Slovenia, Spain, Sweden and Switzerland) allow part of the obligatory practical driving training course to be held on a simulator (CIECA 2010, P. 43 f.).
- For periodic training, most EU countries do not oblige professional drivers to participate in practical training in a real vehicle or on a simulator (CIECA, P. 23 f.). Although this does not exclude practical training courses in a real vehicle or on a simulator, it can nevertheless be assumed that the lack of compulsory, practical training has a negative effect on participation in simulator-based, periodic training courses.
- An obligation for professional drivers to undergo practical, periodic training courses exists only in Denmark, France, Hungary and the Netherlands. According to the CIEKA poll, these countries also provide the option of using a simulator. These countries allow practical training of 30 minutes on a simulator from a total 90 minutes (Denmark) or 120 minutes (France, Hungary). The Netherlands does not stipulate a maximum duration for simulator training, although at least 2 ½ hours must be driven in a real vehicle (CIECA ebenda).

  When Directive 2003/59/EC was implemented into national law in Denmark, a part of the training content to be taught, including the content for simulator training, was laid down for periodic training. Apart from a compulsory, 3-day programme with clearly prescribed topics, professional drivers in Denmark must take part in a training programme put together on the basis of 26 officially approved courses.

  Of these 26 courses, the following four are foreseen for simulator training:

  - Defensive driving
  - Environmentally-conscious driving
  - Driving with new technologies

- Sector-related driving (CIECA ebenda).

This extensive pre-structuring of the training content reflects the aim of the legislation, which is namely to ensure a high quality implementation of the EU directive.

In summary, it can be said that the opportunities for simulator training in initial qualification can be seen as quite positive in most EU countries – particularly as the directive stipulates obligatory, practical training courses. Yet due to the lack of legal specifications for integrating practical training courses in periodic training in the majority of EU states, the opportunities for simulator-supported further training courses can be regarded as quite limited.

The examples of Denmark, France, Hungary and the Netherlands nevertheless show that the EU directive can also be applied to anchor obligatory, practical training courses in law. The allowance for simulator training in the further training regulations in these countries means that simulators can also be used here as an alternative to training in a real vehicle. This opens up further possibilities for simulator training in these countries, comparable with those involved in initial qualification. Yet whatever the case, driving simulators were introduced into only a few transport undertakings during the implementation of EU Directive 2003/59/EC.

It should be mentioned in conclusion that the evaluation of the implementation of EU Directive 2003/59/EC by the European Commission has not brought any recognisable changes for simulator training to date. The evaluation report generally gives the impression of confirming the directive's current application practice. Apart from clarifying rules of exception in cross-border traffic, the Commission's report only sees the need for improvement in coordinating "the national differences in the time schedules for periodic training" (see EUROPEAN COMMISSION 2012, P. 16).

In the following section, we intend to identify the reasons why the opportunities for simulator training created by the resolution of EU Directive 2003/59/EC have not been used (or have not been able to be used) to date.

3. Simulator training in practice

Against the background of the opening of the legal system for the deployment of simulators in initial and advanced training for professional drivers described above, the resolution of the directive in 2003 awoke high hopes that these opportunities could soon be exploited. The German simulator researcher Käppler (2008), for example, welcomed the opening of the European Union's legal system as "going down new roads", whilst research initiatives, such as the TRAINALL project sponsored by the EU under its 7th framework programme, was expected to boost simulator training in Europe (Bekiaris et al 2009). In reaction to the introduction of EU Directive 2003/59/EC, the Transport Research Laboratory (TRL) ran a research programme initiated by the British Ministry of Transport to establish the potential of simulators in supporting initial and advanced training for professional drivers (Read and Lang 2011, P.1).

Driving simulators at that time had only been operated in Europe for purposes of research, but were now introduced by some transport undertakings and training centres. This led to a minor boom from 2004 to 2006, during which time the majority of the six or seven of the mid-range simulators accredited in the EU for training bus drivers that are currently still in operation were introduced.

The positive expectations on the financial benefits to be reaped from simulator training (on which these investments were based) turned out to be without substance.

We have been able to identify the following reasons for this:

3.1 Application of Directive 2003/59/EC

As practical elements of periodic training are not compulsory in the majority of EU countries and these training elements are generally more expensive than teaching theory in a classroom, this legal situation has generated a structural discrimination against practical training courses. This concerns training both in real vehicles and on simulators.

The consequence of this is that the lucrative further training market created by the enforcement of EU Directive 2003/59/EC as from 2009 has basically remained closed to simulator operators. In contrast, practical courses to train drivers for initial qualification is a field of activity that has low access barriers due to the legal obligation to undergo

practical training. For the handful of driving simulator operators (some of whom may attempt to occupy niches in the qualification market by means of specific features), this is also the focus of their simulator-supported training activities (see Grüneberg et al 2011, P. 10)

This business model may not be sufficient to generate profits from simulator training, or to even cover costs.

Such a conclusion is suggested by the two contributions on the deployment of driving simulators at the "Information and Initiative Days (I&I Days) on Directive 2003/59" held in Brussels in 2010. Both contributions claimed that simulator training cannot be operated profitably under the current legal framework conditions. This message was also reflected in a press release of 23rd March 2011, which can be found on the web site of the only simulator operator in Denmark (TransportSektorens Uddannelsesfond 2011). The press release reports that new regulations for promoting employment had led to a collapse of demand for simulator operations, thereby threatening the continued existence of the operator, and a solution to the problem had still not been found. This situation was unexpected in view of the simulator-friendly legislation in Denmark described above (including the obligation to participate in practical further training) and the exceptional economic position of the operator as the sole provider of simulator-based qualification services in the entire country.

On the other hand, these problems experienced by the operator show that the causes of the difficulties in running simulator training at a profit, or to even cover costs, are not to be found solely or even mainly in the legal framework conditions.

3.2 Cost efficiency of simulator training

A central factor in assessing the cost efficiency of simulator training is the price difference between a driving simulator able to obtain accreditation and a real exercise vehicle (a truck in the example below). Such price differences have represented a barrier to the economic operation of driving simulators to date. Christie (2003, cited from Dorn and Edmunds 2012, P. 2) states in this context:

"Cost efficiency remains a major topic because full-mission truck driving simulators are more expensive than the costs of training in a truck. Simulation must be very effective in this case or

the value of training under hazardous conditions and situations needs to be demonstrated. In the majority of cases, it is cheaper to train drivers in real cars or trucks on real roads and is more realistic and effective than deploying car or truck simulators. In addition, obtaining access to real vehicles and real roads is often easier than accessing the limited number of driving simulators." (translation U.G.).

The situation for full-mission driving simulators for trucks discussed here also applies to mid-range driving simulators, even after almost a decade. Despite the fact that simulator development has participated in the enormous progress made in computer technology, forecasts that cost reductions, allied to better performance of the simulation technology, would overcome the price difference between a simulator and a real bus or truck (see Dorn and Edmunds 2012, P. 2) have not been able to be confirmed. The case studies performed in the STB project into European simulator operators show that the mid-range simulators examined were considerably more expensive than the real vehicles otherwise deployed. These simulators cost around € 500,000, making them something like twice as expensive as the real buses deployed for conventional training (priced around € 250,000).[3]

In contrast to the foregoing situation, the situation in the simulator price range up to 100,000 Euro with mid-range/low cost simulators is a little more encouraging. A Polish delegate at the TTD Conference (Technology-based Training for Drivers) in Dresden on 23-24 November 2011, for example, reported that 14 simulators in this price segment had been installed in training centres in Poland over the last few years (see Piorunkiewicz 2011).

The simulators approved for training professional drivers by the Polish authorities (see Professional Driver's Training 2011, also see Lozia 2011) are deployed in combination with an online e-Learning programme for initial qualification. This low threshold access to qualify as a professional driver is apparently not restricted to Poland. According to the web site of the simulator manufacturer Dr. Foerst of 26/09/2012, the Ministry for Transport and Infrastructure of the German federal state of Baden-Württemberg had issued approval to the company to deploy its truck simulator for holding courses for accelerated initial qualification and to perform further training courses in economic driving, so-called "Eco-training" courses (see truck simulator 2012**).**

[3] The American study "Commercial Motor Vehicle Driving Simulator Validation Study: Phase II" established that the costs saved for one driver participating in simulator training came in at only US $ 35 compared to a driver trained by conventional means (see Morgan et al 2011, P. 118).

3.3 Recruitment and qualification of simulator instructors

The STB project (a predecessor of the SIMTEB project) offered the opportunity to examine the personnel and organisational prerequisites for introducing simulator training in the form of case studies into three simulator operators. The main findings of these (unpublished) case studies on the aforesaid subject are discussed below.

A particular problem confronting the simulator operators proved to be that it was almost impossible to recruit suitable instructors for simulator training on the job market. Furthermore, it is not always possible to recruit staff from the existing pool of driving instructors. This is because instructors who previously worked in conventional vehicles (and even performed well above average in these) had great difficulties in adapting their know-how to simulator training.

There are no institutions for training instructors for simulators in the EU at present. There are likewise no intra-Community, uniform, teaching schedules for simulator-based training that are commonly applicable (Bekiaris et al 2009, S. 7).

Due to the lack of facilities for training instructors, it was mainly left to the simulator operators themselves to build up the necessary expertise, generally under difficult operating conditions. Some operators therefore experienced considerable problems in commissioning their simulators and the results of training remained below expectations. The potential of the simulators deployed was not able to be fully exploited during the first years of operation. This led some operators to deploy their simulators rather like a real vehicle, without really being able to get the most out of the technology, as this can only be exploited by intelligently designed scenarios (also see Weiß et al 2009, P. 10).

In addition, the (further) development of training modules proved to be a weak point in the efficient use of simulators. This is a question of adding new skills in social dealings with learner drivers to the experience accumulated by driving instructors and of getting to know the simulator, so that its specific features are understood.

The extended profile of requirements expected from simulator instructors and developers includes the following:

- Replacing the traditional role of driving instructor (as someone who primarily acts as a director, controller and disciplinarian) with that of someone who offers advice, support and motivation

- The ability to use the simulator as a modern, pedagogic instrument. The professional experience accumulated must be used to develop instructive exercise scenarios, in consideration of the specific depiction features offered by the simulator, and taught in interactive processes with the trainees on the simulator with an eye to media pedagogics.

As a rule it is two people, although sometimes just one, who have acquired the knowledge and abilities required for this job, often over a longer process of self-qualification.

The fact that the training itself and the development of training modules was concentrated on a few key individuals led to some considerable problems in continuing training on the simulator if such key individuals left operating company and no-one could be found to replace them at short notice.

If the commitment of these key individuals had been a major factor in the decision to introduce simulator training in their organisation, their departure weakened the internal support for simulator training in the organisation. If the introduction of a simulator had been a bone of contention from the start, the departure of these promoters often led to a step-by-step marginalisation of simulator training.

Such a development makes clear that the inclusion of simulator training in a corporate culture open to changes is of central importance for permanently anchoring this in the system of initial and further training in the respective organisations. The methodical procedure used to introduce a simulator training programme into the corporate culture of their organisation was seen by drivers in two large transport undertakings in the USA as the key to the success of the programme in their companies (Morgan et al 2011, P. 163).

3.4 Exchange of experience and transfer of knowledge

Whilst simulators to train drivers were being introduced, the operators of driving simulators began to exchange experiences. This was set against the background of the unresolved problems of recruiting and training instructors in order to make the most of the features offered by the simulators. One of the aims of this exchange is to build up efficient training structures. On the one hand, this exchange of experience is arranged by European organisations, such as the European Transport Training Association EUROTRA (see TSU Danmark organises First Expert forum 2009). On the other hand, extensive

contacts have arisen between individual operators that are maintained by the undertakings involved themselves.

There are also stand-alone activities aimed at transferring knowledge of the efficient deployment of simulators from research institutes to the area of application. For example, some operators received support during the introduction phase from experts drawn from universities in the development of a training programme (see Muncie and Dorn 2003b), or the findings of many years of experimental research into simulator driving with the aim of saving fuel were tested with commercial users under practical conditions (Read 2010).

However, the various activities to exchange experience between the simulator operators and also the transfer of knowledge from the field of research to the application level have had only a limited effect. This is because these activities were mainly limited by time and the levels of research, development and application had hardly been networked at that time. These activities were not able to solve the problems existing in the introduction and operation of simulators, even though it may be assumed that some operators were able to continue their simulator training thanks to the opportunity of exchanging experience.

3.5 Areas of deployment for simulator training

This section intends to analyse a range of topics for simulator training and identify approaches for designing the content of basis modules for simulator training in Europe.

Major considerations in selecting the range of topics for simulator training – as was discussed under 2.1.2 – are the legal framework conditions governing the design of content for training professional drivers and the approval of teaching schedules or of framework programmes by the competent authorities in the individual EU countries. Although there are no intra-Community directives or guidelines, which the competent authorities in the individual EU countries can use as orientation for approving suitable teaching means, quasi standards for selecting the teaching materials to be used have prevailed via the market in some EU countries. According to investigations made by the ProfDRV EU project, which examines the opportunities presented primarily to professional truck drivers by EU Directive 2003/59/EC (see ProfDRV 2012), the majority of teaching schedules in Austria and Germany are developed by publishing houses (BOS, Ebner and MMM in Austria; Vogel, Degener and Hendrisch in Germany). These schedules are closely related to the knowledge and abilities laid down in Annex 1 of EU Directive 2003/59/EC. Training centres generally use one of these books or the software

offered for their training programmes. Standardised materials are also available from various publishers in Italy. (Bacher et al 2011, P. 3).

In countries with more or less standardised training materials and modules, the question is the extent to which new modules, as currently being developed in the SIMTEB project, can obtain approval from the competent national authorities. Obtaining approval for training rooms to hold lessons in theory in accompaniment to simulator training is likewise turning out to be more difficult than expected in some EU countries.[4]

The areas in which the few operators of simulators for training bus drivers are active are analysed against this background. This analysis aims to obtain pointers for designing basis modules for the European framework concept to be developed for simulator training. Information available to the general public, particularly from the Internet, together with information collected in case studies during the STB forerunner project, was evaluated for this purpose. The table on the pages below gives an overview of the results of this evaluation. The results show clear overlaps between the modules offered by five providers of training courses for bus drivers. The fact that the contents of the training programmes offered by the European simulator operators are quite similar is not pure coincidence. They conform to the main contents stated in the EU directive as coming into question for practical training.

The following focal points were identified in the services offered by the five European simulator operators:

3.5.1 Eco-driving

Eco-driving is at the forefront of simulator deployment, this being practiced by all operators and offered to all customers. Although the declarations made by each of the operators on Eco-driving activities vary between economic, environmentally-friendly and energy-efficient driving, the common aim of these activities is nevertheless to conserve fuel, with an according reduction of costs and lower pollution of the environment.

The statements made by these operators concerning the technical driving methods to conserve fuel correspond to the recognised “golden rules of Eco-driving”**.** The “before & after” comparison of the curves of consumption and the inclusion of practical training in

[4] It is not possible for a German project partner to hold training sessions in a specially fitted truck which conforms to the legal requirements at present. The reason for this is that the minimum size of training rooms (compulsory) stipulated by the competent authority cannot be complied with. This takes no account of the fact that simulator training is performed with a very limited number of participants.

pedagogic courses of information and motivation are the methodological state-of-the-art, and was formulated as follows during the STB project:

"The module to be developed is based on a systematic analysis of objectives and requirements on simulator-supported training. The training is embedded in upstream and downstream exercises held outside the simulator. These exercises and the simulator-supported training are regarded as a single unit. Under the aspect of the success of the training, theoretical and practical methods of acquiring knowledge are combined in order to teach an in-depth understanding of the objectives of Eco-driving. For example, by combining training on a simulator with discussions in small groups, CBT and class room teaching." (Minutes STB Meeting 2011)

Simulator operator	**Services for training bus drivers in simulators in the EU***		
	Eco-driving	**Defensive driving**	**Safe driving**
FCBO (BE) www.fcbo.be/view_pages-2-opleidingsaanbod.html*	Course: Economic and environmentally-friendly driving Influences on fuel consumption Identifying the consumption of fuel in the course of the journey Optimum use of the rev counter Comparison of curves of consumption before and after Realisation of the fuel saved Other techniques to save fuel	Course: Defensives driving Driving in city centres Driving on roads in the vicinity of the bus station Entering and exiting motorways Approaching crossroads with priority to vehicles coming from the right Practising evasive action at crossroads Changing lanes on roundabouts	Course: Safe driving in mountains Optimum use of the rev counter Different braking systems and their hazards Techniques for driving round bends Safety on steep inclines How to react in emergencies The affects of driving round bends and speed on the passenger side Course: Safe driving on slippery roads Driving on slippery surfaces Different braking systems and their dangers on slippery surfaces Dangers of speed and turning on slippery surfaces
DB (DE) www.db-training.de/site/dbtraining/de/seminarfinder/fahrzeugfuehrer/Kf1203.html	Course: Bus economy practical training: Driving for the pleasure of conservation Targeted reduction of fuel consumption Reducing wear and tear on the transmission, brakes, tyres and chassis Conserving the environment Reducing operating costs without prolonging driving times Understanding the economic significance Recognising and adapting own driving habits. Practical driving training Evaluation of results		
TSU (DK) www.amusyd.dk/amuupload/syd/Image/AMU_Uddannelserne/Relateret_Materiale/Transport/Simulatoruddannelser.pdf	Course: Energy-efficient driving Optimising fuel consumption in order to reduce operating costs and lower environmental pollution Acquisition of knowledge on the technical, physical, meteorological and topographical conditions that influence fuel consumption Knowledge acquired in the real world and in virtual reality optimises fuel efficiency, minimise maintenance costs, reduce stress and lower environmental pollution Identification of stress factors which affect driving behaviour	Course: Defensive driving Assessing risks and appropriate conduct in difficult traffic situations that suddenly occur. Manoeuvring the vehicle in static accident situations which occur with particularly frequency. Correct steering and braking, correct evasive action on normal, wet and icy roads, in poor visibility, on level and hilly terrain.	
TTS (FI) www.tts.fi www.i-and-i-days.eu/ppt/13_Lybeck_2010.ppt*	Economic driving Exercise drive in the same conditions at the start and the end of the training course	Defensives driving/proactive driving Avoiding hazardous and threatening situations Driving at night Driving on snow covered or icy roads	
	Basis skills for economic and defensive/proactive driving: Correct approaches to merge with traffic		

	Frugal use of the engine Correct gear changing Influence of acceleration of fuel consumption		
EMT (ES) http://www.dvr.de/ttdconference/download/ttd2011_deke_ppt_en.pdf:	Energy-efficient driving Conserving fuel: economic driving training.		Safe driving Reducing accidents (special programme for drivers involved in several accidents)

* Source: Apart from using material recorded internally under the concluded STB project and the on-going SIMTEB projects, the information in this table was called up from the Internet on 20th August 2012 and – except for the DB training – was translated into German.

An initial attempt to implement these criteria was undertaken by the STB project (see Module for safe and fuel efficient simulator based training for bus drivers 2011). This module is being further-developed into a basis module for the European framework concept for simulator training in the on-going SIMTEB project.

3.5.2 Defensive driving, safe driving and avoidance of accidents

"Defensive driving" is stated as a field of deployment for simulator training by three operators and "safe driving" by two operators. On closer inspection, however, considerable overlaps become apparent between these two disciplines.

The areas of application for simulator training described here are primarily those that can be allocated to anticipatory driving to avoid accidents – a driving style which requires the driver to anticipate what other drivers are going to do at an early stage and adjust to different weather conditions in good time. Examples of such are approaching and practising "evasive action at crossroads", approaching "roundabouts", training in "correct steering and braking" and training "correct evasive action on normal, wet and icy roads, on level and hilly terrain".

Eco-driving and defensive driving are seen in the SAFED programme run by the British Ministry of Transport as the two focal points of simulator deployment. In the Transport Research Laboratory (TRL), "the main building blocks of the SAFED programme were transferred to a simulator-based training programme for the truck driving simulator from EADS used there as a research simulator" (Reed and Lang 2011, P. 5). The training programme is described in detail in the unpublished case study "Simulator based fuel-efficiency training on the TRL truck simulator" (case study 2011).

3.5.3 Dealing with critical driving conditions and traffic situations

There is a clear distinction between training to avoid accidents and training aimed at mastering critical situations. The central objective of training to avoid accidents is to anticipate such situations or to learn how to “deal with hazardous situations” on a simulator. However, action to cope with accidents only plays a marginal role in the programmes offered by current simulator operators (for training bus drivers). The extent to which the content described here includes elements to cope with accidents needs to be clarified in detail with the simulator operators. Training to master critical, accident-prone traffic situations could nevertheless become a subject in qualification, particularly in periodic training for professional drivers, in the medium or long term. Krüger (2006), for example, sees new elements for training drivers in the simulation of “difficult situations”, which “seldom occur in real-life”. Teaching skills to avoid accidents places high requirements on the technical fittings of a simulator. In the interests of greater traffic safety, however, the ability to deal with hazardous situations should be part of the programme for training professional drivers; even though such situations are not very likely to occur, they still pose a high risk.

Conclusions

The following conclusions can be drawn from what has been discussed above in order to develop a framework concept for simulator training:

- Further develop the existing “Eco-driving/energy-efficient driving” module into a basis module in the framework concept for simulator training
- Develop a further basis module for “defensive driving to avoid accidents” in consideration of the adaptation of the SAFED programme to the requirements of simulator training in the training programme for the TRL simulator.
- Develop a basis module for “mastering critical road and traffic situations”/ “driving to avoid accidents”

We assume that these three modules proposed for the European framework concept to be developed cover the central topics of simulator deployment. This naturally does not exclude other topics being taken into account, such as those identified by the Association of German Transport Operators (VDV) for training public service bus

drivers[5], in the development of national or company-specific programmes for simulator training. The content of the concepts and programmes for simulator training lastly need to be adapted flexibly to the particular practical requirements.

4. Summary and outlook

An overall review of the prerequisites for introducing driving simulators produces a not very conducive picture with only partly open structures outside and inside the organisations. These are the constraints that confront the first movers in the industry in their efforts to build up a stable, economic and social basis for sustainable operation of simulator training.

Despite some interesting examples of national implementation, EU Directive 2003/59/EC hardly provides any incentives for simulator training. The particularly concerns the expanding market for advanced training expected from the enforcement of the EU directive. However, the vague regulations of implementation in 2003/59/EC actually send out negative incentives for performing practical training courses. This situation presumably increases the wariness of the customers of training centres towards comparatively unknown simulator training.

In addition, “top-of-the-range simulators” are generally too expensive compared to a real exercise vehicle. Tangible evidence of the potential benefits offered by simulator training over the long term, especially cutting fuel consumption and reducing the number of accidents, cannot be delivered at present due to the financial and practical constraints and the complex methodological prerequisites involved in performing an empirically valid evaluation study.

The problems of finding suitable instructors for initial and advance training on simulators point to the lack of structures for “training the instructor”, both inside and outside the operator organisations. Furthermore, a corporate culture exists among some simulator operators, which is not really open for simulator training. The line managers responsible for simulator training could therefore not always count on support from top management

[5] Alongside “Economic, energy-saving and environmentally-friendly driving” and “Safe driving on the roads”, which can be regarded as more or less identical to the two topics discussed above, the VDV requirements also state “Breakdown management” and “Customer services“ as topics (see VDV notification 9041 2008).

in difficult operational situations, whereby the long term operation of simulators in the organisations is threatened.

Against the background of this restrictive situation for introducing and developing simulator training, the question has to be asked: what are the perspectives for these new training methods?

Perspectives for simulator training

A change in the limited opportunities described above for developing training courses on a simulator for professional drivers most likely depends upon

- the developments that take place in the social surroundings of the current and potential users of simulator training and
- whether simulator operators are able to develop a market strategy for simulator training, one which produces a sustainable demand for this qualification service.

Some developments that offer interesting perspectives for simulator training are discussed below.

1. Major changes in the legal framework conditions governing simulator training cannot be expected from the few proposed improvements – which only touch upon peripheral aspects – contained in the first “Report of the Commission to the European Parliament … on the implementation of Directive 2003/59/EC” (EU Commission 2012). This means that the not very conducive legal structures at European Union level will continue to exist. The fact that even simulator operators in EU countries (such as Denmark) with more favourable legal prerequisites are facing financial problems is evidence that legislation alone is no guarantee for economic survival.

2. However, elbow room in the existing legal framework conditions has possibly not been sufficiently exploited. As can be seen from the example of the official approval given to low-cost simulators for initial qualification in Poland, the leeway allowed in defining the term “top-of-the-range simulator“ appears to be much greater than experts thought possible at the time the EU directive entered force.

3. New assessments of the potential offered by simulator training to conserve fuel

can be expected in the wake of rising prices for petrol and diesel. Eco-driving, in particular, has already become the main area of application for training bus drivers in simulators. This could prove to be the engine driving greater demand for simulator training, if transport undertakings feel that sending their drivers on the Eco-driving courses offered by the simulator operators will “pay off”.

The strategy of reducing CO2 emissions pursued by European Union (see reducing emissions from transport) can certainly be regarded as helping to promote simulator training. The chance to reduce fuel consumption through Eco-training could also lead to a forced application of simulator training for this reason.

4. An important step in involving the simulator operators in solving these social problems would be to answer the question of whether simulator training is a more efficient training form compared to conventional training, from both a professional and an economic aspect. This would require the performance of an empirical validation study with a broad remit.

5. One of the central problems in introducing driving simulators is the optimum use of a simulator by deploying suitable courseware and qualified staff. Such courseware needs to be adapted to requirements and, if applicable, to the specific operational needs.

   The products to be developed in the SIMTEB project should help to reduce these problems. This firstly concerns the development of a European framework concept for training bus drivers on simulators, and secondly the development of guidelines to train the instructor. Both instruments need to be evaluated to establish their suitability for practical application.

6. A further problem is the low level of exchange of experience between the institutions and organisations dealing with the question of state-supported simulator training in their different functions. Cooperation between the research and application levels, in particular, is often limited by time and focused on just a handful of contact persons.

Building up a social network across Europe, and possibly even beyond, could provide some relief here. Current and potential users of simulators, as well as researchers and developers in this field, could exchange experiences in such a network, put their products up for discussion and possibly provide a database for the users of the network free of charge. Assuming good intentions on the part of those involved and professional and socially ambitious coordination, the development dynamics of social media on the Internet could be successfully used to promote an innovative form of training in state-supported transport applications.

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6. Appendix: Specifications of the simulators examined in the STB project [6]

Simulator-operator	TRL (UK)	TTS (FI)/FCBO (BE)	VAG (DE)	FIRST (UK)	KIEROWCA (PL) (Daten werden ergänzt)
Common information					
Classification	High End	Mid-Range	Mid-Range	Mid-Range	Mid-Range/Low cost
Manufacturer	EADS	Simrac	Corys	FAAC	Foerst
Year of introduction	2003	2004/2006	2011	2006	2010
Accredited	???	yes	yes	no	yes
Price	3 Million €	ca. 500 000 €	ca. 500 000 €	ca. 500 000 €	95 0000 €
Global concept					
Fixed/mobile	Fixed, large room	Fixed, large room	Mobile, in a 6 m trailer	Fixed, standard room	Mobile,
Cabin					
Full cabin (original)	Pod mounted	Front part of a coach / truck genuine cabin	Genuire parts and rebuild parts	Rebuild with genuine parts, reduced width	open
Generic					
Seat/dashboard	Genuine	Genuine	Genuine, with pneumatic settings	Genuine	
Controls/displays	Original / fixed	Genuine / fixed	Genuine / fixed	Genuine / fixed	
Visual System					
Field of view (horizontal)	270°	> 180°	210°	> 200°	180°
Number of channels for outside direct view	7	4	4 + 1 (bottom of passengers door)	5	
Number of mirrors	2 + kerb mirror	2 (outside)	2 outside (3 channels), 1 inside (2 channels)	2 + inside mirror/camera on rear door	
Display/Projection System					
Projection (Beamer) ➢ rear projection ➢ front projection ➢ screen projection ➢ windshield projection	Front projection cylindrical screen	Rear projection	Front projection, ultra-short throw	Rear projection boxes	
Display	For kerb mirror	For mirrors	For 3 mirrors, 1 TV for	For mirrors, back screen	

[6] This table was taken from the concluding report for the Leonardo Da Vinci Project "Simulator-based training for bus drivers“ (STB) (see Grüneberg et al 2011, P. 28) with a few, minor changes added. These changes concern the deanonymisation of the abbreviations of the operator names. Due to the internal nature of this report, these changes should not pose a problem. The Polish operator KIEROWCA was also inserted into the table because this community of training centres deploys a total of 16 simulators (of which 11 of the type presented here). Missing specification data of the operator were added. The bus simulators of Messrs. TTS and FCBO are the same model. The “common information” field was added to the table with primarily non-technical, basis information on the surroundings of the simulators deployed.

➢ LCD-Monitors ➢ TV screens (LCD)			passengers door botton	and actual mirrors with flat glass	
Simlator-operator	TRL (UK)	TTS (DE)/FCBO (BE)	VAG (DE)	FIRST (UK)	KIEROWCA (PL) (Daten werden ergänzt)
Motion System					
Full / part	Full cab and visuals	Full cab	Seat	None	
Technology	Electrical with pneumatic compensation	Pneumatic	Electrical	None	
Actuator driven MS ➢ Numbers of DOF	6 (6 electrical actuators)	3 (4 actuators)	3 (3 actuators)	0	3
Database					
Type of roads ➢ motorway ➢ trunk road ➢ urban road ➢ suburban roads ➢ others ➢	All, 100 km in total	All, about 1000 km of roads in a 200 square kilometers area	All, mainly city streets including pedestrian areas and tramway lines	All, mainly city streets	
Traffic environment ➢ geotypical ➢ geospecific	Geotypical	Geotypical, geospecific bus terminal	Geotypical, but inspired from Nuremberg, with 1 geospecific bus line and	Geotypical	
Traffic simulation ➢ intelligent ➢ deterministic ➢	Deterministic	Deterministic	Intelligent	Intelligent but cannot be mixed with event controlled vehicles	
Event control ➢ offline ➢ online (while a running session)	On and off line	Offline	Mainly offline, online interaction with auxiliary driving station	Mainly offline, online interaction with auxiliary driving station (out of use)	
Session /exercise edit ➢ by the trainer ➢ by the manufacturer ➢	By the trainer	By the trainer	By the trainer	By the trainer (but not user friendly)	
Weather / road conditions ➢ dry ➢ wet ➢ fog ➢ snow ➢ rain ➢ day / night ➢ others ➢	All, including road friction, wind gusts	All	All, with icy patches	All (snow ?)	

Observers view yes / no	Through instructor station	Through instructor station	Through instructor station + additional monitor	No	
Simlator-operators	TRL (UK)	TTS (DE)/FCBO (BE)	VAG (DE)	FIRST (UK)	KIEROWCA (PL) (Daten werden ergänzt)
Types of vehicles ➢ truck ➢ bus ➢ coach	Truck. Modular design enables the cab to be exchanged to a bus or coach cab for example	2 Coach simulators	1 City bus 12m, articulated city bus 18m	1 City buses (single, articulated, double-decker)	11 Bus/Truck-Simulators
Dynamic conditions ➢ axles ➢ gross weight ➢ loading (full/half/empty) ➢ passengers	Rigid (26t GVW max.); Semi-articulated (44t GVW max.). Load can be 0% (empty) through to 100% (full) and configured as Solid or Liquid (trailer/rigid load takes on appearance of liquid tank) or Hanging. For solid loads, the centre of gravity can be adjusted to one of nine positions. Dynamics of the vehicle change according to the overall configuration chosen.	?	Passengers, with influence on load	No passengers	
Assistance systems regarding to eco driving training ➢ retarder ➢ wear-free brakes ➢ graphics / alpha numeric display showing: ➢ fuel consumption ➢ CO^2 emissions ➢ amount of brakings ➢ amount of gear shiftings ➢ momentum ➢ ACC (adaptive cruise control) ➢ Speed limiter	➢ Retarder ➢ Green zone on tachometer ➢ Automated driver feedback on all driving parameters and outcome measures in terms of CO^2 and fuel savings (expressed in litres and monetary units)		➢ retarder: yes ➢ wear-free brakes: not applicable graphics / alpha numeric display showing: ➢ fuel consumption: yes ➢ CO^2 emissions: yes ➢ amount of brakings: yes ➢ amount of gear shiftings:not applicable ➢ momentum: no ➢ others: use of accelerator pedal; vehicle acceleration		