SIMTEB

Simulator-based Training
for European Bus Drivers

Lifelong Learning

Development of a European framework for a simulator based Training of bus drivers (Result 3)

- Modul Eco-Driving -

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General

Compared to simulator based training of other traffic carriers, simulator based education and training of bus drivers in Europe is playing a minor role. As a consequence of the entry into force of the EU Directive 2003/59/EC and its national implementation into German law the situation has not improved. The optional recommendation to simulator use for limited subject areas leads to a conventional training of all relevant topics on grounds of costs. Currently, the Latter is one reason why the benefits of simulator based training have no chance. The discussion about simulator based training yes or no is reduced to a discussion primarily about cost aspect.

The central areas of investment and throughput are in focus. As long as the effectiveness of simulator based training is ignored, i.e. a simulator hour is set equal in their effectiveness with a real driving lesson, simulator based training will always be more expensive than a conventional training using a stock vehicle. Unfortunately learning effectiveness, efficiency and sustainability remain ignored in this discussion.

The dominant opinion on the level of investment is still nourished by prices that were actually prevailed about 10-15 years ago for a driving simulator. Since then the technological performance has improved exponentially and prices for system components have fallen because commercial components (COTS) are essentially used. In addition, many potential simulator users still have an idea of a simulator which can be described as "full mission" simulator.

Experienced simulator users as well as academic experts tend to the fact that less complex simulators perform their training tasks very well, when these tasks are specified precisely enough. This fact is supported by public funded studies such as “ELSTAR[1]”,”TRAINER[2]” and “TRAIN ALL[3]”. Also studies on cost-benefit ratios[4/5] show that simulator based training is comparable with conventional training based on the use of original vehicles. But this, however, only possible under the premise that simulator hours are accepted as equivalent driving lessons. To meet these conditions, given legal framework in Germany must be adapted.

The concept described below reflects that proven training concepts, proven hardware and software developments can be used transnational to reduce the cost of simulator based training through synergies.

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[1] European Low cost Simulators for the Training of Armed Forces; EUCLID RTP 11.8, 2000

[2] System for driver **Tr**aining and **A**ssessment using **In**teractive Evaluation tools and **R**eliable methodologies“, Competitive and Sustainable Growth, 2002

[3] Integrated System for driver Training and Assessment using Interactive education tools and New training curricula for ALL modes of road transport, Final report, 2009 (http://www.transport-research.info/web/projects/project_details.cfm?id=36286)

[4] Commercial Motor Vehicle Driving Simulator Validation Study: Phase II, U.S. Department of Transportation, Federal Motor Carrier Safety Administration, 2011

[5] Using simulators to train and assess drivers – A focus on category D simulators, 2010 Driver Competence Seminar, Jan Deman, FCBO

European Framework Concept

The European framework concept of SIMTEB is based on the project objectives:

- Transfer and operational implementation of an innovative training concept for drivers and trainers in initial and continuing vocational education and training organizations in public urban transport in Europe.
- The promotion of a sustainable use of simulators in the bus branch, based on a concept for the training of bus drivers and the development of trainer skills.
- Realizing an important contribution to safe and environmentally friendly driving, how it meets the intentions of the "EU Directive 2003-59/EG".

Therefore SIMTEB deals with the realisation of transfer of innovation by the adaptation and development of products for the simulator training: The Finnish training concept was developed to an European framework for the simulator assisted training and completed by a guideline "Train the Trainer" for this training module. Both products were tested, evaluated and optimised.

The simulator operator in France and Finland integrated the developed training concept and the developed guidelines for training of the trainers in their regular training programmes. Further implementation and dissemination of the training concept and the guideline were done in national and transnational conferences and seminars.

The development of the existing training concept of the STB project and the innovation giver TTS in Finland to a European Framework Concept (European added value, general character) has to be oriented at a general objective:

> *The European Framework for the simulator based training of bus drivers will guarantee fuel saving and comfortable driving, more secureness of passengers and drivers. This will lead to more cost and environmental effectiveness as well as to more service quality and less stress for the drivers.*

Basic learning outcomes / training sub-modules raising from the state-of-the art report of SIMTEB (also proved by the German VDV guidelines) are:

- Eco-driving: reducing fuel and low carbon
- Safety: Defensive, accident free driving, securing safety of the passengers
- Risk and emergency management: capabilities to behave adequate in risk situations
- to be included in all the sub-modules:
  Customer friendly driving: guaranteeing the comfort of the passengers.

Given the fact, that SIMTEB is a transfer of innovation and not an innovation development project the following operative approach was selected by the partners, supported by the advisory board:

- Eco-Driving was chosen as an overarching and in-depth tested module or model for the other three topics/modules, including parts of safety, customer orientation and risk management.
- The other three additional sub-modules could be easily modified on the background of the results of the eco-driving module and the tested practicability and acceptance (interviewing trainers, drivers and experts).

Requirements (supporting and inhibitive factors, user related requirements) for the improvement and implementation of eco-driving via simulator based training could be taken from the state-of-the art review (result 2), the test and evaluation (result 5 and 6), the optimising improvements (result 7) and the policy recommendations (result 8):

An integration in vocational education and training programs is still necessary, including accreditation and validation of learning outcomes (e.g. via ECVET credit points). This could be easily done by the basic training orientation of the eco-drive module:

- Outcome orientation, transparent training results
- Individual training scenarios and group training
- Feedback, reflection of the driving situation (by the trainers and the peer-group of trainees)

Beneath the golden rules for eco-driving (see result 3) general principles for a Simulator Based Eco-Drive Training underline this orientation:

- Pick up of the trainees where they are regarding to the topics of eco-driving.
- Convince the trainees that the way to successful eco-driving is a mental way.
- The training is conducted as a highly interactive problem oriented training.
- The trainees should be actively involved in the problem-solving.
- The simulator is not a driving “game”; primarily the simulator provides discussion points.

Initial situation

The basic idea of this study was to examine whether and if so under what conditions a successfully introduced simulator-based training concept can be transferred to another training facility (transfer of innovation).

Subject of the transfer is a simulator based training concept on eco -drive training for bus and truck drivers, developed and successfully used by the Finnish project partner TTS, an education and research and development facility. Based on this concept TTS is running a simulator-based education and training for professional drivers for several years certified by the Finnish regulatory authorities.

The vocational training center Nordhausen (BBZ), an education and training center for professional drivers in Germany, should integrate the concept successfully into its regular training schedule. BBZ is running conventional eco -drive training for several years, using an original vehicle.

The content of the training concept should be a training session for ecological driving which meets the continuing education criteria of the EU Directive 2003/59 EC, namely an one-day training of 7 hours. The French project partner Corys TESS provided a prototype of a medium complexity bus simulator to BBZ.

Based on the project experience a European framework was developed and tested as an example of an Eco-drive training. This concept can be used after adaptation to the local conditions of each training provider and to the applicable national legal requirements in the European country.

Concept design

Two concept areas must be distinguished:

1. the didactic concept of the eco-drive training (overall concept),
2. the didactic concept of the specific simulator training.

Both levels cannot be treated in isolation, they must refer to each other. On the question of how to transfer concepts, the relationship between two concept areas has to be clarified. In the present case it is clear that the methodological-didactic concept of the eco-drive training is the leading concept. The methodological and didactic concept of the simulator training must be integrated into the leading concept.

After several mutual hospitations at specific training sessions it quickly became apparent that the methodological and didactic approach to eco -drive training at the innovation provider (TTS) and the innovation provider (BBZ) shares very similar goals and methods.

In simple terms, the training takes place in the following steps.

a) Introduction
b) 1 Simulator ride (data collection, State of the Art)
c) Technical information for eco-driving (golden rules, etc.)
d) 2 Simulator ride (data collection, data comparison)
e) Debriefing

Both training institutions place great importance on communication between participants and trainers and among the participants themselves.

With the comparability of the methodological and didactic approaches to eco-drive training in educational institutions an important prerequisite for the transfer of the simulator-based training concept was met.

Training concept for simulator based eco drive training (framework)

Didactic approach

Besides cognitive and psychomotor aspects the learning and training objectives for eco-drive training are characterized by a high proportion of affective aspects. Because the simulator attracts cognitive and psychomotor aspects more than psychomotor aspects it is important to integrate the simulator into a communication oriented training concept to meet these behavioral units in simulator based training. In addition to the simulator, the coach plays an important role. Change of behavior requires insight and understanding. That is why great

communicative parts in the training process are needed. These are initiated and moderated by the trainer.

Thus the role of the simulator is clearly defined. The simulator brings insights to life, provides impetus for thematic discussions and for an exchange of personal experience. Leading idea of this approach is the belief that learning does not takes place in the simulator, but rather by the exchange of experience within the training group after the simulator rides. So it becomes clear that the simulator is not the leading actor in the training, but the qualified trainers and the trainees themselves.

The theoretical content is represented by the trainer in an information block, i.e. the technical aspects behind fuel consumption and CO_2 emissions. The practical options to influence fuel consumption and CO_2 emissions shall be developed by the trainees themselves (small group work) and shall be tested in short simulator rides.
In essence, it involves the following "golden rules":

- Anticipate traffic flow, use momentum, avoid unnecessary stops,
- Maintain a steady speed at low RPM,
- Shift up early,
- Use assistance systems (retarder) correctly

All activities that contribute to an ecological driving style are discussed. For the implementation into the simulator program, the above mentioned activities are used because they are easy to handle in a simulator.

Important inputs for the discussion and group work arise from the targeted observations of the simulator rides run by another trainee. Here the current non-driving group members are actively involved. If the driver does not understand the observations, the teacher can run a replay of the current drive. For the debriefing of the trips the simulator provides measurement data demonstrating the success or failure of each driving behavior. The interpretation of the data is carried out together with the coach.

As in the conventional training two comparison drives will be performed to document the training success. The first ride shows the eco-drive performance before the training, the second ride documents the eco-drive performance after the training. In the individual debriefing the amount of fuel saving is an important point, but it should not be overvalued. Additional to the reduction in fuel consumption the documented changes in driving behavior are of great importance. This shows whether the driver has understood the relationships and is able to implement an appropriate driving behavior or not.

Training schedule

The training is designed as a one-day seminar for 6 participants. More than 6 participants would require one more trainer because the group has to be separated. For a communication oriented training on a simulator the maximum number of 6 drivers has been proved to be practicable for one trainer. As the observation of each active driver by the non-driving

trainees is an essential aspect of simulator training, a higher number of trainees would lead to an extension of the observation times. This might be perceived as boring for the non-drivers. Targeted observations related to specific driving behavior (speed, rpm, gear changes, stops, acceleration, etc.) will be integrated itno the entire group in each simulator ride.

Time	Topic	Method	Remarks
08:00 – 08:15	Welcome / Overview / Organisational	Flip Chart / prepared papers	
08:15 – 08:45	Round of introduction	individual each participant	e.g. collecting expectations
08:45 – 08:50	Explaining the simulator	Trainer – at the simulator	
08:50 – 09:30	Familiarization drive	Each student e.g. 4-5 min.	Easy to drive task
09:30 – 09:45	Break		
09:45 – 11.00	Driving the first ride	Each student about 10 min.	Observing tasks for other students
11:00 – 12:30	Eco driving - Golden rules	Elaboration of the golden rules in small groups	Group work, discussions
12:30 – 13:00	Break		
13:00 – 13:15	Golden rules – driving a bus	Repeating	
13:15 – 14:15	Driving experience	Students have different tasks (golden rules) driving the simulator	Observing – Evaluating
14:15 – 14:30	Break		
14:30 – 15:40	Driving the second ride	Each student about 10 min. including individual debriefing	Observing tasks for other students
15:40 – 16:00	Conclusions	Lessons learned	

This training sequence corresponds to the temporal criteria of the EU Directive 2003/59/EU

Driving scenarios

The description of the driving scenarios, i.e. the description of the driving course, the traffic conditions and disrupting events, is based on normal everyday driving situations in urban bus services. The principle of didactic reduction will be applied namely to divide complex tasks into simple elements. Experiences of classic eco Drive training show that no complex scenarios are required. Instead the driver should learn to perform eco-related behavior in typical driving situations.

Therefor simple and manageable traffic situations are best suited[6]. More complex situations can be the subject of further trainings.

Experience has also shown that no site-specifically route data bases are required but geo typical forms are adequate.

To become familiar with the simulator behavior a simple exercise drive with low traffic is recommended. Important subjects of a familiarization ride are operating the vehicle to experience the steering and handling and to get a feeling for the visual representation as well as for the noise simulation.

The comparison drives (1st and 2nd ride) are kept similar for better comparability.

For the practical development of eco -drive principles (golden rules) and the testing of their effects short scenario sections will be helpful. The sections can be copied from the comparison scenarios or can be developed as short special scenarios. These scenarios contain simple route sections as well as simple traffic situations such as approaching a traffic light crossing, behavior on increasing / descending routes, threading into moving traffic, etc.

The following descriptions are based on conceptual decisions by a SIMTEB working group.

[6] Keep it small and simple

Scenario 1: Familiarization drive

Briefing	Instruction for operating the bus, the controls, the route, the traffic, etc.
Target	To become familiar with the simulator. This applies in particular to the characteristics of the steering, the brakes and the vehicle dynamics.
Database	Outside of the city, 2 lane road. Traffic signs in relation to national legislation in Finland and Germany. Summer time, daylight.
Starting point	Bus stop with shelter. Some passengers waiting, if possible enter the bus.
To start the bus	Typical starting procedure after the start signal given by the trainer. using rearview mirrors, etc.
Traffic	At this time, low density traffic flows in the opposite lane
Entering the lane	Using the rearview mirrors and setting the left indicator, the bus is set in motion.
Acceleration	Driver accelerates the bus up to 30-50 km/h.
Database	Traffic sign with a speed limit of 60km/h approx. 30 meters behind the bus stop. Driver is able to recognize the traffic sign during waiting at the bus stop.
Database	After speeding up to 30 - 50km/h (depends on the driver) the bus is approaching some wide curves (left/right).
Continuing the ride	After passing the curves the bus approaches an intersection with traffic lights. Leaving the last curve, the driver can see the traffic light showing green.
Database	Traffic signs 250 meters before the intersection: traffic lights 250 meters ahead, maximum speed 60 km/h.
Continuing	Approaching the intersection, traffic light colors changes green > yellow > red. Driver can stop easily.
Traffic	Waiting at the red traffic light, traffic is crossing from both sides, some cars turns right or left. Waiting time approx. 15 seconds.
Database	Leaving the intersection the plane road changes into a hilly road. Traffic signs: minimum speed 60km/h, maximum speed for busses and lorries 80 km/h.
Database	After 500 meters traffic sign to delete the maximum speed, after 100 meters the maximum speed is set to 60 km/h
Database	300 meters behind the maximum speed limit of 60km/h a traffic sign announces the next bus stop in 200 meters.
End of session	Bus stop with shelter. Some passengers waiting.

Scenario 2: Comparison drives (pretest/retest)

For the comparison drives (first ride / second ride) identical scenarios are used. Driving time approximately 7 minutes (+ / -)

Target	**Collecting individual performance data**
Database	Industrial area, 2 lane roads,
Starting point	Bus stop, crossing with traffic lights 50 meters ahead, traffic lights can be seen by the driver during waiting at the bus stop. Passengers are waiting, some entering the bus. Traffic in the other direction (comes from the left crossing lane), low traffic in own direction.
Start	Leaving the bus stop traffic lights are still on red. Driver is entering the traffic by waiting for the proper gap to merge.
continuing	Accelerating in the proper way. Close to the traffic light (20 m) it switches to green. Also passenger lights switches to green. If possible, some people are walking or standing beside the road, if possible, some people are waiting at the traffic light for to cross the road on the crosswalk (Navigation by sign or voice).
continuing	After some 100 meters the bus is approaching the next bus stop. Driver brakes smoothly (passenger friendly). There are some passengers waiting at the bus stop. If it is not possible to place some passengers at the bus stop, there must be a bell on the bus, which indicates to the driver that a passenger wants to get off.
continuing	While the passengers are entering/leaving the bus, the bus driver noticed the changing of traffic lights from red to green. The crossing is located about 150 meters behind the bus stop. Driver receives a delay message (+ 3 minutes). Target: to give pressure to the driver to pass the crossing during the traffic light is still green. It depends on the driver's behavior if he reaches the crossing at green or not. Does he bear the golden rules in mind? etc.
Database	Behind the crossing the road design changes to a normal road with a bus lane.
continuing	After the bus has crossed the intersection, the driver changes to the bus lane. After about 150 meters the bus approaches a slow driving garbage truck on the bus lane. The bus driver has to reduce speed and to keep a minimum distance (safety distance) to the vehicle in front.
Database	Bus lane ends
continuing	At the end of the bus lane driver must enter the normal traffic flow. The bus is approaching an accident the vehicles hinder the traffic flow. The bus has to pass the obstacle carefully. Target: Observing the traffic from behind.
continuing	Continuing on the 2 lane road. Pedestrians (far) in front of the bus are crossing the road. Parking cars right/left the roadside. Target: Traffic observation, to reduce speed. It could be possible, that a hidden person enters the road.
continuing	The bus is rolling with an appropriate speed.
End of course	The bus approaches to the next bus stop. Passengers are waiting. The bus driver brakes smoothly and comes to a stop.

Despite the simplicity of the scenarios can be noted that the drivers have perceived these as very practical.

Debriefing

The debriefing of each simulator ride is an important prerequisite for the subsequent learning process. Here the driver's own feelings are mirrored against the impressions of the observer. In order to objectify the statements of the observers the trainer can draw on a number of documented data provided by the system as log data.

The following data have proved to be helpful

- Driving time
- Speed (average, maximum)
- Elasped distance
- Keep a safe distance
- Acceleration (appropriate, powerful)
- Deceleration (appropriate, powerful)
- RPM (RPM level red, yellow, green))
- Fuel consumption (current, average, maximum)
- CO_2 emission (current, average, maximum)
- Number of total stops.

The following indicators must be visible at all times for the observers

- Current speed
- Current speed range
- Current switching stage / gear selection
- Current fuel consumption
- Current CO_2 emission

A further observation target for example is the drivers behavior. Does he drives carefully? Does he use mirrors? etc.. In any case, the observations should refer to relevant aspects of eco Drive.

How the observations can be done is a question on the system configuration. In the simplest form the observers are standing around the simulator vehicle. Poorly visible indicators should be displayed on separate monitors. Convenient configurations have an own observation station, where all indicators including the driver’s view onto the road can be observed during the whole session. The integration of the entire training group in the practical drives is one of the most important didactic elements of the training concept.

Reviews or corrective comments from colleagues are much more easily accepted as annotations of the trainer. For the coach it is important that he does not lose his way of a classical driving instructor

Summary

Experience has shown that the described "eco-driving" training module can be adapted easily by other training institutions. This framework could be easily integrated into the training of TTS and BBZ.

It became clear that different simulators and data bases can be used. The respective simulator equipment as well as the respective options for exercise generation must allow the adaptation of exercises to eco drive criteria.

Important prerequisites for a successful transfer are:

- Consensus between users on basic approaches to the respective training such as eco Drive training or driver safety training
- Consensus that 60-70% of learning takes place not in the simulator but next to the simulator.
- Qualified coaches for the didactics and methodology of the simulator-based training are available.
- The adapting training facility has appropriate hardware and software resources.

Technical Requirements

The comments on BKrFQG (professional driver qualification law), the national implementation of Directive 2003/59/EU, allow the use of a simulator for specific training contents unless it is an efficient simulator. In a so-called handout[7] a powerful simulator is described in detail. Unfortunately, the description is very general so that manufacturers of simulators of all complexity levels feel concerned.

Technical requirements for a training simulator do not make sense without the description of the training objectives. But for the basic equipment profound expert knowledge is acquired.

[7] On 8 March 2007 it has been agreed between federal and state governments that the BMVBS will support a recommendation on the use of a "powerful simulator" pursuant to § 2 paragraph 3 sentence 4 BKrFQV, which is also in accordance with EC law.

Vehicle Cab	Generic, realistic driver‘sworkplace, enclosed cab is not required
Controls	Fully, positioning (handling lengths) realistic: levers, switches, pedals, steering wheel. (Steering wheel position adjustable)
Haptics	Realistic feedback forces, pressure points, etc.
Seat	Realistically, adjustable
Visual displays	True replica of vehicle instruments (speed, revolution counter, gear level, fuel consumption, etc.)
Motion	A motion platform to simulate dynamic driving forces is not required. A device that is initiating shocks or vertical vibrations into the seat will be sufficient for most training goals.
Driving / Vehicle dynamics	The impression of reasonable driving dynamics (acceleration / deceleration) must be mediated through the visual representations associated with the corresponding motor sound..
Acoustics	Realistic display of driving and vehicle noise. Retarder in use.
Visual representation	Full HD, large screen monitors or projection, FOV≥ 180 °(H) ≥ 45 °(V), rear view mirror and side mirror views on se parate displays
Data base	Geo specific, locations based on learning objectives, useful route length approx..: 30 km, different routes can be combined.
Database configuration	realistic configuration of the traffic area, diversified track geometry and track topography, realistic traffic flow (high number of road users (> 150), great variety of road users, variable density of the autonomous traffic
Didactical aspects	
Driving data display outside the driver's workplace (e.g. observation station)	Display a driver's perspective, perspective freely selectable Display of standard driving data Display of relevant driving data related to learning objectives
Development of driving exercises	Editor to create / customize exercises
Training minutes	Documentation of important driving and exercise data. Can be set by the trainer for logging. Alpha numeric display and / or simple graphics.
Replay	Recording and playback ability of the currently running exercise. Free choice of viewing perspective. Continuation of the driving session from a particular replay position. Save the recordings as video files.

Overall it can be said that the requirement priorities have shifted from hardware to software. So the effort to build a simulator cabin with a high degree of reality as well as the integration of a realistic motion simulation can be seen more critical today. This is both for cost as well as didactic reasons. Probably, the influence of these components in the achievement of general learning objectives in the field of driver education and training is overestimated.

With respect to the assumption that 60-70% of learning takes place next to the simulator, the demand for high-performance software tools to support the trainer in the initiation of learning processes seems to be plausible. This also applies to the content and quality of the presentation of traffic and traffic area. The visual system must generate and present realistic visual stimuli. The visual representation must be able to drag the driver in the virtual world[8].

The requirements described above are to be understood as references for potential users who wish to procure a bus simulator for their training. Of course, the training and the achievement of learning objectives with a more complex simulator is possible. Although full cabins and 6 DOF motion platforms are not required they do no harm when they are available.

Anyway, simulators are didactic tools in the hands of experienced trainers. They do not replace the real vehicle. In addition to the hardware basic equipment, it is the software, the training concept and the qualified trainers which make the simulator to an effective training tool.

Summary

1. Within the SIMTEB project it has been shown that a simulator -based eco Drive training can be carried out successfully.
2. It has been shown that a simulator-based training concept can be successfully transferred from one country to another country.
3. A data base specially designed for eco driving is certainly the best solution.
4. Eco Drive Training can also be carried out with small adjustments in existing data bases.
5. Trainers must be qualified for the didactic use of the simulator.
6. The simulator is a powerful tool which allows making complex contents to life. The simulator generates triggers to start a learning process.
7. Successful simulator-based training requires not necessarily a highly complex simulator. Not the technical feasibility, but the didactic need defines the requirements for a simulator.
8. On the basis of the experience made in Finland and Germany the presented concept can be used as framework in order to transfer the concept in other European countries.

[8] Empowering Simulation – Visual Simulation in the Key, MT&SN Vol. 13, Issue 2 2011

9. Simulators are didactic tools in the hands of experienced trainers. They do not replace the real vehicle. In addition to the hardware basic equipment, it is the software, the training concept and the qualified trainers which make the simulator to an effective training tool.