European Commission

Information Society

6th Framework Programme - Priority 2 "Information Society Technologies"
"**HUMAN centred design for Information Society Technologies**"
Proposal n° **507 420**
Contract n° **507420**

Universidad Politecnica de Madrid
Profesor Aranguren s/n
28040 Madrid
Spain
Tél : +34913366652
Fax : +34913366654
e-mail : jmpardillo@caminos.upm.es
http://www.upm.es

Guidelines for the development of a European driver training and education tool

Deliverable G4 of Task Force G: Use of ITS to train and to educate drivers

Reference: **GUPM-061030T1-AB**

Rev.	**Issuing date**	**Pages**	**Written by**	**Visa**	**Verified by**	**Visa**	**Approved by**	**Visa**
A	30/08/06	28	Jose M. Pardillo	√	TFG	√		
Modifications: creation of the document								
1	30/10/2006	28	Jose M. Pardillo	√	W. Jansen I. Spyropoulou	√		
Modifications: Changes to version 1 suggested by T.Troglauer (pp. 2,7,11,12,13 and 21); W. Vlakveld (pp.7, 11, 12 and 17), Y. Barnard (pp. 8,10, 11, 12, 15, 17, 19 and 21) and C. Turetschek (pp.6/7/10/11 and19)								
2	30/12/06	27	Jose M. Pardillo					
Modifications: Changes to version 2 resulting from the peer review process								

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Previous Humanist TFG work resulted in the assessment of the state of the art in the application of driver simulators to driver training, and the identification of additional research effort that is needed to achieve the potential effectiveness in using simulators to improve the driver training process.

The next step in the TFG work plan was the elaboration of Guidelines for the development of European driver training and education tools. For this purpose a Conference on European guidelines for the application of new technologies for driver training and education was held in Madrid (Spain) on April 24 and 25, 2006.

Based on the conclusions of the Conference and on the results of the previous activities of the Task Force, Guidelines for the development of a European driver training and education tools have been elaborated by the Task Force.

The Guidelines contain a series of recommendations that are intended to provide guidance in the development of driver training and education tools, and background information that supports these recommendations.

1 INTRODUCTION

Humanist TFG seeks to identify the areas of training where simulation can be brought in to help provide the necessary skills to drivers. The objectives of the Task Force are:

- The application of new ITS technologies for the driving education of novice drivers to facilitate the development of safety behaviour and the risky situations awareness.
- The application of new ITS technologies for the training of elderly and disabled people in the aim of functional awareness.
- To explore the potential of applying e-learning techniques to driver training and to conduct an analytical review of driver training and education to use in formulating guidelines and goals for future development of learning tools.

A variety of driving simulators is available nowadays covering a wide range of specifications. It is thus possible to implement different driver training applications with a growing level of complexity and fidelity to real driving conditions. Nevertheless, there is a lack of common technical specifications both at national level and at European level that define the minimum conditions that a simulator should have to be suitable for use in the different levels of driver training applications.

E-learning techniques are starting to be used in this field. In general e-learning denotes all kinds of techniques using electronic means or multimedia to enhance traffic safety through improvement of drivers' skills and knowledge. As such e-learning techniques can employ strategies, which range from training of certain skills or techniques to improvements in awareness of special subjects. A large amount of e-learning applications are currently on the market for commercial use either as educational tool for driving schools or by individual students. The range of areas within the driver training process which they cover is wide, although an overall assessment of the extent of use among driving schools and instructors in Europe is not available. There is also a lack of specifications of the aspects of driver training for which e-learning techniques are best suited for and should be applied.

Previous TFG work resulted in the assessment of the state of the art in the application of driver simulators to driver training, and the identification of additional research effort that is needed to achieve the potential effectiveness in using simulators to improve the driver training process.

A workshop on the Application of new technologies to driver training was organised by Humanist TFG at the CDV facilities in Brno (Czech Republic) on January 25-26 2005. During the workshop 20 papers were presented, and 30 researchers from Humanist partners discussed the requirements and research needs in the field of driver training.

Based on the conclusions of the Workshop, the Task Force continued working on two areas:

1. Study the functional requirements of driver education tools and identification of research needs to fill the gaps in existing simulator and multimedia tools.

2. Analytical review of driver training as well as education process and identification of potential applications of e-learning.

These two studies provided the base for the preparation of the report on functional requirements of driver training and education tools, identification of research needs and potential applications of e-learning (Pardillo et. al., 2005).

As few TFG partners had been involved in either development or use of e-learning applications, the studies were complemented with results from the project TRAINER, which addressed issues relevant for driver training and specifically put them within a context of multimedia or simulator use relevant for driver training.

The next step in the TFG work plan consisted in the elaboration of Guidelines for the development of European driver training and education tools. For this purpose a Conference on European guidelines for the application of new technologies for driver training and education was held in Madrid (Spain) on April 24th and 25th, 2006. The event was hosted by the Technical University of Madrid (UPM).

During the Conference, researchers in human factors, driving simulators technology, and e-learning from the Humanist partners, shared their experiences with experts from other European research centres, public institutions and private companies with interests in the different aspects of drivers training. In total, 42 researchers representing 23 institutions and companies from Austria, the Czech Republic, Denmark, France, Germany, Greece, the Netherlands, Norway, Spain, Sweden, and the UK took part in the Conference.

Relevant issues for the preparation of the Guidelines were discussed in the following areas

1: State of the art on driver training methodologies and curricula

2: Recent advances and development needs in driver simulators technology

3: E-learning applications to driver training

4: Novice drivers training

5: Training of older drivers and drivers with disabilities

6: Validation of simulators and training methodologies

7: Functional and methodological requirements

8: Final debate and conference conclusions

The Proceedings of the Conference are available through the Humanist Web Site (www.noehumanist.org/documents/Deliverables/TFG).

Based on the conclusions of the Conference and on the results of the previous activities of the Task Force, the Guidelines for the development of a European driver training and education tools that are presented in this document were elaborated. The text contains a series of recommendations that are intended to provide guidance in the development of driver training and education tools, and background information that supports these recommendations. In the text, the recommendations appear in highlighted case on a grey background.

2 GENERAL FRAMEWORK OF DRIVER TRAINING

Driver training needs to encompass a theoretical and a practical component, which should enable the student to both acquire abilities to master the driving task by means of an abstract approach and through practical training by driving in a real vehicle in real traffic.

2.1 Theoretical background for driver training

Driver training curricula are based on theoretical assumptions about driver behaviour and the driving task. A common premise is that driver behaviour is organised in four hierarchical levels described by Keskinen [1996], building on previous work by Michon [1985 and 1989]. Based on this work the European project GADGET addressed issues relevant for driver training and particularly training of novice drivers in order to provide a theoretical framework to define and comprehend the areas of competences that driver training and education need to address. From this project the GDE-framework (Goals for Driver Education) was developed (fig.1).

The GDE-framework compromises two dimensions. The first dimension includes the three hierarchical levels mentioned above – the strategic, tactical and operational level, but a fourth level is also added concerning "goals for life and skills for living". (the highest levels ranked first). In:

- Goals for life (personal motives and beliefs): this level is based on the assumption that lifestyle, social background, demographic variables as ., have an influence on driving behaviour, accident involvement and attitudes towards driving. As such this level refers to personal motives and tendencies in a broader perspective than simply conducting the driving task. The assumptions behind this level is based on knowledge that lifestyle, social background, gender, age and other individual preconditions have an influence on attitudes, driving behaviour and accident involvement.

- Goals and context of driving: This level focuses on the context in which driving is performed, particularly, on choice and planning of trips, travel-mode, time of day, road situations or driving under the influence of deteriorating conditions or substances.

- Mastering of traffic situations: The conditions applied to this level refers to the mastering of adaptation to specific traffic situations, such as overtaking, speed choice, perception of hazards.

- Vehicle manoeuvring. The lowest level refers to vehicle control such as shifting gears or steering manoeuvres. On this level are also included evasive manoeuvres, control in different weather conditions and use of passive safety measures such as seatbelts and airbags.

This hierarchical approach assumes that abilities and preconditions on a higher level influence the demands and preconditions on lower levels and vice versa.

In addition to the four levels of driver behaviour, the GDE-framework also operates with another dimension, which is formed by three goals for training:

- Knowledge and skills: this level refers to the skills a driver needs for driving under different circumstances.

- Risk-increasing factors: this level deals with aspects of driving or traffic that can increase the risk, such as worn out tyres, perception of the traffic situation, speed adjustment, risk acceptance.

- Skills for self-assessment: this level emphasises how the driver is capable of assessing the performance on the four behavioural levels. It really points to critical self-adjustments of everything from skills in vehicle handling to reflection of individual risk attitudes.

These dimensions relate to behaviour at the different levels thus influencing both the preconditions of driving as well as the accomplishment and execution of the driving task.

Traditional driver training typically only covers the last two levels of behaviour (vehicle manoeuvring and mastery of traffic situations). Similarly, at the goals dimension level only the first level of knowledge and skills is included and to a lesser extent risk increasing factors are covered in existing training schemes. The third level is rarely encountered during driver training. On the contrary, in training of professional aircraft pilots this is an important topic in the curriculum.

.

Ideally, driver training curriculum should cover all the areas of the framework and address the appropriate driving behaviour associated with them.

Hierarchical level of behaviour	Essential contents (examples)		
	Knowledge and skills	Risk-increasing factors	Self evaluation
Goals for life and skills for living (general)	Knowledge about/control over how life-goals and personal tendencies affect driving behaviour • lifestyle / life situation • group norms • motives • self-control, other characteristics • personal values etc	Risky tendencies • acceptance of risks • self-enhancement through driving • high level of sensation seeking • complying to social pressure • use of alcohol/drugs • values, attitudes towards society etc	Self-evaluation/ awareness of • personal skills for impulse control • risky tendencies • safety-negative motives • personal risky habits etc
Goals and context of driving (trip related)	Knowledge and skills concerning • effects of trip goals on driving • planning and choosing routes • evaluation of requested driving time • effects of social pressure in car • evaluation of necessity of trip etc	Risks connected with: • driver's condition (mood, BAC etc) • purpose of driving • driving environment (rural/urban) • social context and company • extra motives (competing etc) etc	Self-evaluation / awareness of • personal planning skills • typical goals of driving • typical risky driving motives etc
Mastery of traffic situations	Knowledge and skills concerning • traffic rules • observation/selection of signals • anticipation of course of situations • speed adjustment • communication • driving path • driving order • distance to others / safety margins etc	Risks caused by • wrong expectations • risk-increasing driving style (e.g. aggressive) • unsuitable speed adjustment • vulnerable road-users • not obeying rules / unpredictable behaviour • information overload • difficult conditions (darkness etc.) • insufficient automatism/skills etc	Self-evaluation / awareness of • strong and weak points of basic traffic skills • personal driving style • personal safety margins • strong and weak points for hazard situations • realistic self-evaluation etc
Vehicle manoeuvring	Knowledge and skills concerning • control of direction and position • tyre grip and friction • vehicle properties • physical phenomena etc	Risks connected with • insufficient automatism/skills • unsuitable speed adjustment • difficult conditions (low friction etc) etc	Awareness of • strong and weak points of basic manoeuvring skills • strong and weak points of skills for hazard situations • realistic self-evaluation etc

Figure1: GADGET-MATRIX

2.2 Basic vehicle handling skills

Training the basic vehicle handling skills is a natural feature of driver training. But in order to enable trainees to cope with new technical devices, like ACC or ABS, it is necessary to implement lessons that take these new developments into account.

Simulators can be used for training the first steps of vehicle handling. The advantages are safety related – trainees could learn these skills without endangering themselves or other road users, and also related to environmental preservation since the use of simulators instead of practice on a motor vehicle eliminates the pollutant emissions that the later creates.

Trainees should learn to know or better experience the risk increasing aspects of the tasks, especially underestimation of speed. To enable trainees to evaluate their skills in a realistic way they should have the possibility to compare their estimates with the real outcome.

2.3 Cognitive aspects and decision process

Novice drivers lack perceptual skills and anticipation in traffic. On the one hand they do not use peripheral vision and on the other hand they underestimate the time needed for many manoeuvring tasks, like overtaking, merging, lane changing, reaching an intersection, stopping, and turning. They have problems to estimate the behaviour of other road users as well, i.e. how much time these drivers need to perform the tasks mentioned above. When an unexpected and unusual situation does occur, they do not know how to react adequately.

To train these cognitive skills the usage of filmed clips, videos or digital media, where the trainee has to detect certain cues, to predict, what could happen and what he/she would do is suggested.

The main advantages of simulators compared with real cars are that trainees can experience scenarios, which are too dangerous to create on the road, and that trainees can train cognitive skills without fully automated manoeuvring skills.

Recent developments in software make it possible that drivers in a simulator could behave in very realistic way. Automatic Traffic Generation and Autonomous Driver models reproduce the circumstances in real traffic, and enable the users to repeat and therefore train certain tasks in changing environments, with varying risk, and different road users, with variable behaviour. With these devices it is possible to train anticipatory skills, like risk or hazard perception, which are highlighted by recent research as very important for safe driving.

Through the combination of opportunity to practice and obtaining feedback on those skills trainees can come to their own understandings of how cues in traffic and a possible outcome are related. Moreover, trainees can experience the results of their own risky choices. However, risky driving behaviour results not only from poor perception, but also from overestimation of own skills.

In order to increase driving skills without increasing excessively the self confidence of the trainees the manoeuvring component should not be overemphasised. It is preferable to include in the training process demonstrations and exercises in which novice drivers may fail in order to develop a realistic self-evaluation of their capabilities.

2.4 Strategic tasks

Trainees should be aware about there motives for driving and the serious effects these motives can have on the driving performance. It has not yet been determined to what extent drivers can be trained in these aspects through multimedia techniques.

2.5 Motivational and self-evaluative aspects

Knowing the relations between driving style on the one hand and personal tendencies, social pressure and lifestyle on the other hand, could enhance the trainees´ awareness of their higher risk in accident involvement.

Trainees should be given comprehensive feedback on their attitudes, risk perception and personal tendencies during training.

Self-assessment tools like questionnaires and scales, discussions with other trainees about personal experiences and evaluations made by instructors or examiners seem to be appropriate educational methods.

Trainees should know or better experience in a simulator which harmful influences on driving behaviour factors like stress and mood could have and how drivers can cope with these risk increasing aspects.

Training safe driving strategies can only be successful, if driver training covers the whole range of contents, and consequently it should also include motivational and self-evaluative aspects.

Demonstrations should also be used to convince trainees to comply with safety related regulations (e.g. use of seat belt).

3 TARGET GROUPS FOR DRIVER TRAINING

When discussing issues of driver training, it is useful to distinguish between the target groups e.g. whether it is a training of novice drivers or rather a retraining of professional or experienced drivers. Though an overlap occurs between the different groups, as they have to abide the same rules and regulations, training typically rest on different approaches to the driver.

Novice driver needs to acquire both theoretical and practical skills and knowledge at all levels of the GDE-framework, whereas training of experienced or professional drivers typically is directed at more specific areas of the driving task.

Similarly, training groups of elderly or disabled drivers would have to implement different approaches such as the obtainment of functional awareness of their abilities and limitations and to adapt their driving behaviour accordingly without being exposed to the risks of real traffic.

3.1 Novice drivers

Novice drivers are the group with the highest accident risk. Fatality rates for 18-24 year old drivers (number of driver fatalities per million age group) in industrialized countries are about double those of experienced drivers (25-54 years of age). In the first years after having passed the driving test, the accident risk declines sharply. Several studies have found that the accident risk decreases rapidly during the first years of driving experience (Turetschek, 2006). It takes however about 7 years of driving experience before the accident risk reaches an acceptable low level.

Three main causes are mentioned in the literature why young drivers are greatly over-represented in crash and fatality statistics:

1. Lack of experience.
2. Biological, sociological and psychological traits of young persons.
3. Gender, as the accident rate of young male drivers is much higher than that of young female drivers even after adjusting for exposure.

Novice drivers need to learn basic skills, like vehicle operation, steering, manoeuvring and interaction with other traffic. These skills may be learnt in a virtual environment in which the complexity of real driving environment can be simplified.

In many European countries, driving simulators are being used for initial driver training. The current generation of low-cost driving simulators can offer such an environment, with traffic in a detailed road environment, providing virtual instruction and feedback on errors. These simulators focus on the didactical aspects, and are integrated with .normal driver training. Without motion or with limited motion base it is difficult to train the control tasks (breaking, lateral guidance...), although it is possible to train *psycho-motricity* (e.g. to change gear without turning the steering wheel).

In depth accident analysis of crashes in which young novice drivers are involved, has revealed that it is not so much a lack of basic driving skills that has caused the accident, but a lack of so called higher order skills. These skills deal with risk perception, risk acceptance, self assessment, the motivation to drive safely, etc. Young drivers tend to misinterpret traffic situations (Renge, 2000), show an inefficient visual search (Underwood et al, 2002) and have difficulties in adapting their speed and driving distance to the driving conditions (Clarke et al., 2005). They also tend to under-estimate the risk of a hazard resulting in an accident and over-estimate their ability to deal with hazards (Deery, 1999).

Anderson (1982) differentiated three stages in drivers' performance patterns. At first (the declarative stage), performance is relatively unstable, as possible strategies are tested and rejected. In case of distraction, task performance deteriorates considerably. After enough practice, one reaches the knowledge compilation stage, during which verbal mediation of performance is far less then previously, and associations between action patterns in familiar conditions become stronger. However, in this intermediate phase, a dual task will still interfere with the primary task. Finally, after more practice and experience, one reaches the procedural stage, at which verbal mediation does not exist, and the task performance is highly consistent and requires almost no effort.

The effects of simulator based training on accident risk have not been assessed yet. There are however indications that simulator training helps to speed up the learning process. In the Netherlands about 100 driving simulators are in use at different driving schools. When students take simulator lessons, fewer hours behind the wheel in real traffic situations with a driving instructor are required in order to pass the driving test.

It is possible that if simulator training helps students to pass the driving test quickly, it could lead to an increase of the accident risk. It is also possible that simulator training results in improved skills as it helps to improve the transition from the *declarative* stage through the *knowledge compilation stage* to the *procedural stage*.

At present, there is not enough knowledge on transfer and retention of the skills that are acquired during simulator training to assess its effects on the performance of the drivers after the training period.

More research on the effect of transfer of training is recommended to determine whether simulator training during initial driver education has a positive or a negative effect on accident risk after the driving test.

Since the higher accident risk of novice drivers does not result only from inadequate basic driving skills, also higher order skills have to be trained in the one way or the other. The simulator training might be used as basis for discussion in order to reflect the behaviour novice drivers showed during the test ride. Next to this aspects related to the levels of the GDE matrix, which are missed so far in driver training, should be risen as well.

Advanced Driver Assistance Systems (ADAS) like collision warning, intelligent speed adaptation (ISA) or lateral control systems have the potential to assist young drivers in reducing their accident risk. Other IVIS devices like navigation systems or travel- and traffic-information-services can support novice drivers, since they can provide them with information to avoid difficult situations. Nevertheless, problems may arise in the driving performance of novice drivers because of distraction or overload. Additionally, when these systems are used, drivers may tend to delegate their responsibility to the system or to misjudge the objective risk in specific situations (Turetschek, 2006).

In the future, training of novice drivers should incorporate instruction on proper and safe use of ITS devices. Discussion and work groups, combined with simulator and multimedia training might be appropriate methods to make novice drivers aware of specific problems in connection with the use of ITS.

3.2 Professional drivers

Professional drivers typically undergo training at the skill and manoeuvring level (i.e. in handling difficult driving manoeuvres, driving special vehicles or goods vehicles).

A smaller amount of the e-learning applications were targeted at professional drivers compared to the number of applications targeting novice drivers. However, most of these used existing driving curricula as the basis for the content. Similarly, it was found that the applications were operating on the control and manoeuvring level, though a few of the applications also targeted hazard detection strategies.

Simulators have been developed both for research and training for professional drivers. Already in 1958 the Iowa State driving simulator linked a vehicle cabin mock-up to a scaled physical terrain model allowing the driver to control actions in a rudimentary road layout. Since then there have been many different technical innovations including video of real scenes and more recently, computer generated environments. At present, several European countries employ truck driving simulators as part of in-service training.

There appear to be four fundamental reasons for the relatively slow adoption of simulation as a key component of professional truck driver training:

- A lack of documented evidence showing a clear benefit of simulation training over traditional on-road and test track methods.
- A concern over the economics of providing high technology facilities and the attendant high costs of entry to the area.
- A concern from the drivers that such training will be additional to, rather than replace parts of, the current requirements.
- The risk of simulator-induced sickness.

The picture, in Europe at least, may soon change. The European Commission Directive on Training for Professional Drivers (EU Commission 2001, and adopted by European Parliament in April 2003) stipulates that all persons wishing to drive Large Goods Vehicles (LGV) in excess of 7.5 tonnes in a professional capacity, will have to undergo training for, and obtain, a vocational Certificate of Professional Competence (CPC) further to the LGV licence. The directive provides a framework for licence acquisition, testing and further skills development.

The total length of *full basic training* in the proposal is 420 hours (12 weeks of 35 hours each). For *minimum basic training* this will be 280 hours. Each trainee driver must drive for at least 20 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 training:

"…on special terrain or on top-of-the-range simulators 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." (European Parliament 2003, p24).

According to the Directive, basic vocational training is divided into three areas:

- Advanced training in rational driving based on safety rules
- Compliance with regulations
- Health, safety, service and logistics

In addition there are other areas of direct relevance to possible simulator training. These relate to:

- Road traffic regulations
- Ergonomic principles
- Behaviour in an emergency situation:

This shows where simulation, and synthetic training in general, could provide a valuable role, but it does not *prescribe* exactly which elements may be suitable, nor *proscribe* those that are unsuitable [Parkes, 2005].

The possible benefits of simulation are clear. There is potential for: control of the training environment, repeatability of specific combinations of features, objective performance scoring, cost reduction and consistent on-line tutorial delivery. The training environment can be prepared to focus the exercises in specific situations due to the ability to remove unessential elements from any particular scenario; and safer, due to the lack of physical risk, no matter how catastrophic the performance failure. On the other hands there are also limits to what training in a driving simulator can achieve.

Extensive research to assess its benefits and the retention of the skills of professional drivers that are acquired through simulator based training is required.

3.3 Older and disabled people training

In 50 years time, the number of citizens over 65 will increase by 100%, to represent 30% of the total population in 2050. Within the 65+ cohort, the prevalence and the incidence of disabilities are larger than for any other cohort [Falkmer, 2005]. In addition to the application of ITS to train novice and professional drivers, another field that is being explored is the training of elderly and disabled people.

Facing approximately 10-20% of the entire future driving population being disabled requires assessments of their fitness to drive, prior to any training or re-training. Driving assessment is, however, a complicated issue. In order to do it scientifically sound, we need to know what driving really is, i.e. we need a commonly accepted normative model of driving. Despite the fact that driving has been an everyday activity for almost 100 years for many people, there is, however, no such general model. Not even the driving test itself is a valid and reliable predictor of who will drive safely and who will not.

Different driving assessment screening tools are tested and used in several clinics on a regular basis. None of them has a sensitivity and specificity of 100%, respectively. This means that in a driving assessment situation, we will face the trade off problem of either reducing capable but wrongly categorized safe drivers' mobility or reducing the traffic safety for all road users by wrongly categorize unsafe drivers as safe.

Disabled drivers are typically trained for the purposes of identifying functional weaknesses thus not for the purposes of training per se but rather to identify which conditions of driving they would encounter difficulties with.

Simulators can be of use in helping the subjects to gain functional awareness of their abilities and to adapt their driving behaviour to them without being exposed to the risks of real traffic.

Simulation can also be a useful too for the assessment of drivers with disabilities. Driving aids could be simulated so that drivers could test them together with the assessor in a safe artificial environment.

Re-training of disabled older drivers requires the development of specific scenarios based on their particular needs.

A first attempt in this direction, based on the GDE matrix, was conducted within the AGILE project [Widlroither et al, 2003].

4 EMBEDDING ITS TOOLS IN THE DRIVING LEARNING PROCESS

The advent of new instructional tools makes it possible to consider the usefulness of the traditional distinction between theoretical and practical learning which are presently employed. Similarly, it needs to be considered that the range of new technologies varies substantially in format offering a variety of different approaches to the training process giving opportunities to consider which tools are most relevant and cost-efficient according to the learning tasks and processes involved.

Different countries employ different driver training models both in relation to the content of the education and requirements of the driving instructor and this fact needs to be considered when implementing the guidelines of new technologies for driver training.

The adaptation of existing training schemes in relation to simulators and e-learning should not only be regarded as an extension or improvement of the current curriculum but also as a possibility to reconsider the pedagogical tools and didactical approaches of the applications.

Two questions are of particular relevance when introducing driving simulators and e-learning in the driver training process:

1. Existing driving training schemes do not encompass all aspects of the driving task and the context in which it is embedded.

An extension of the curricula is recommended to cover all the levels of the GDE-framework.

2. With the introduction of new learning tools and training technologies it is important to consider how the different levels and dimensions of the GDE framework are most appropriately incorporated.

The role of training methodologies making use of new technologies (multimedia, simulation etc.) in the training process needs to be clarified establishing for which cells of the GDE / GADGET – Matrix new technologies are appropriate and what technologies should be used in each case.

From a training perspective an important question is how the transfer of training occurs between the theoretical training into real world driving takes place.

At present, the main research gap is the lack of evaluation (transfer of training) studies with sufficient scientific credibility. Further research needed in this field.

New technologies offer a wide range of new assessing and testing methods, but further research is still needed to specify the optimal role of new technologies for driver assessment and testing.

4.1 Driving simulators

The advantages of using simulators in driver training are numerous: lack of risk, reproducibility of the situations, control of the parameters, time savings, lower costs, etc.

Driving simulators only become an effective tool in drivers training if they are effectively embedded as an integral part of the training curriculum.

A student should progress through the training following a structured path. For this purpose, books, computer based training, simulator and driving in the real world should be integrated. Such integration requires methodical approach, and detailed analysis of the training curriculum, the learning goals and training needs analysis. Ideally, it is performed prior to the acquisition of a simulator system.

Driving simulation can be considered as a form of Scenario Based Training (SBT). An SBT is focused on controlled and systematically constructed scenarios that have been specifically created for training a certain (sub)task. It focuses, more than other forms of training, on the development of practice, diagnosis and feedback. It links training activities to learning goals.

Based on a task analysis, learning goals are derived. From these learning goals, training activities are derived that are modelled in scenarios. These scenarios are presented to the student in the simulator.

A virtual driving instructor allows an instructor to teach multiple students at the same time, and it allows the instructional process to be standardised. However, automated driving instruction is a complex process, requiring an extensive analysis on the selection, timing and form of instruction and feedback. It also requires insight in the state and the mental processes of a student. Human instructors are able to evaluate such processes while virtual driving instructors are currently not.

A simulator is an abstraction of reality, and many aspects cannot be reproduced with sufficient detail or realism.

Human instructors are required to focus the training process on tuning the acquired skills, and on the subtler, higher order, cognitive aspects of the driving task even for the tasks that are trained by the virtual instructor.

The current set of driving simulator lessons is linear: all students go through an identical training curriculum. This ensures that all students have had an explanation of the same basic procedures. This suits well in a highly structured driving course, but it does not fit well to courses that are more flexible. In theory, an adaptive curriculum would allow each student to be trained at his or her optimal learning curve [Kappe et al, 2005].

The core of training programs is not the technology, but the didactics of the curriculum. New technologies offer new training opportunities that require new didactical approaches as well.

Simulator-based driver training should be improved by enhanced didactics using options like replay of critical situations, group discussions at the end of training sessions, presentations of scenes from the perspectives of other road users etc.

Creating traffic scenarios is not trivial. The traffic model should allow a predetermined traffic situation to occur each and every time, on many types of roads, intersections, roundabouts etc. Tutoring requires real time performance recording and evaluation, as well as prioritising and scheduling of instruction and feedback.

More research is needed to tailor simulations /simulator scenarios to the training needs of different driver groups. Training programs should focus on the specific needs of driver groups like professional drivers of heavy vehicles, older drivers (male and female) etc.

For each scenario (and the underlying training activities and learning goals) performance measures are defined. After completion of the scenario, the performance of the student is graded relative to a set of standards. In the diagnostic process, it is determined why the student performed as was observed. Why did an error occur? Were the rules not known, was the sign not observed, or was the approaching vehicle not noticed.

A good diagnosis tool that provides proper feedback is required to focus training on the weak points of the trainee.

Safety performance of drivers trained in this way compared to that of traditionally trained drivers has not been assessed yet. What is known, though, is that the passing rate for the driving test of this short but intensive training programme with the use of modern technology (multimedia training, simulator training) is slightly above average.

It is recommended that research is conducted to determine whether there is a difference in accident rate in the period just after having passed the driving test, between traditionally trained novice drivers and drivers that have attended this new training programme with the aid of driver simulators.

A problem that in some instances has created problems in simulator based training is the appearance of simulator induced sickness, which can affect users of all ages, but to a larger extent to older persons.

While visual perception is dominant in most driving tasks, vestibular perception plays an important role in vehicle control. Vehicles can experience large accelerations as they increase or reduce speed or drive through curves. Advanced driving simulators incorporate motion platforms to simulate these accelerations. However, even with these motion platforms it is not possible to simulate realistic motion cues in all driving situations. As a result, driving simulator users experience sickness in some cases (Espié et al., 2005).

Further investigation on the causes and solutions of simulator induced sickness is recommended.

4.2 E-learning

E-learning or multimedia learning can be defined as the combination of text, graphics, animations, pictures, video or sound to present information (Najjar, 1995). Since these media can readily be integrated by means of computers, e-learning is becoming a more and more widespread tool for training and education within many spheres of society.

Within the domain of driver training e-learning denotes all kinds of techniques using electronic means or multimedia to enhance traffic safety through improvement of drivers' skills and knowledge. E-learning techniques can employ strategies, which range from theoretical knowledge of traffic rules and regulation to training of certain skills or techniques or improvements in awareness of special subjects. Finally e-learning might be integrated as tools for influencing the attitudes of drivers and as tools for self-assessment.

E-learning basically has the potential to move the learning process from the classroom or traditional written curricula into the learners' world, providing access to learning anytime or anywhere without geographical or time barriers.

In addition it is technically possible, e.g. through the internet, to provide immediate access to learning materials and interaction with experts or/and fellow learners. Finally the advancement of computers' capacities makes it possible to illustrate real life driving situations and animated scenarios thus making the experience quite realistic.

It has been suggested that e-learning compared to traditional class room teaching or instructions from text-books, offers several learning advantages on several levels of the learning process (Najjar, 1995):

- Instructional methods: Multimedia instruction may force the instructional designer to organise and structure the learning material compared to traditional class room teachings. This is particularly the case when using complex and large amounts of learning material and when a large degree of freedom in information gathering is possible for the learner.

- Interactivity: Can be thought of as mutual action between the learner, the learning system and the learning material. Compared to traditional learning forms multimedia learning offers a high degree of interactivity due to the integration of written and illustrated contents. There is a tendency for e-learning material to be more interactive than traditional textbooks and classroom teachings.

- Control of learning pace: Multimedia to a large extent allows the learner to set the pace of learning thus offering the possibility of adjustment of content to individual needs and preferences.

- Novelty: Information presented though various sources (audio-visual and illustrative examples) may be more stimulating than material presented through traditional means. It has been suggested that initial positive findings from multimedia learning compared to traditional classroom learning stems from the fact that multimedia was a novel experience.

- Individual design: it is possible to adopt instruction and feedback to the learning style and capabilities of the trainee

Though the above mentioned aspects of learning processes advocate strongly for the use of multimedia as learning tools in general and within driver training in particular, it has to be emphasised that these are aspects of the learning process, which can be better utilised in multimedia environment than in traditional learning environments. It does not imply that multimedia per se has a superior effect over traditional teaching methods. As such it has not been consistently proven that use of several media in instruction is superior to one media instruction though research evaluations of multimedia instructions suggest that if utilised efficiently and appropriately certain advantages will persist.

E-learning can facilitate the abstract and practical learning process of traffic (safety) concepts and rules. As such e-learning should not be regarded as tools to replace real/practical driving training.

E-learning can provide cost effective training tools to increase knowledge on specific aspects during the training process, to raise awareness or simply to illustrate specific traffic situations.

E-learning applications can be used in conjunction to other training courses or as activities in simulator courses. The learning outcome will depend to a large degree on the pedagogical approach to the whole learning process in driver training.

It might be stated that the use of multimedia in driver training should include a thorough understanding of the subject of driver and training in relation to the task of driving.

In relation to the GDE-framework, the TRAINER project found that the content of the training through e-learning are primarily aimed at the control and manoeuvring tasks, and do not address the strategic level of driver training to an extent desirable and thus utilising one of the potential benefits of the interactive multimedia [Hoeschen et al, 2001]. Recently e-learning applications have also attempted to address the higher order skills like hazard perception, situational awareness and self assessment and it is likely that a substantial amount of applications already exists on topics related to driver training or safety e.g. defensive driving, hazard perception or driving fuel efficiently.

It is recommended that a comprehensive review of the extent of usage of e-learning applications for driver training at European level be conducted, and a synthesis of best practices be prepared

5 FUNCTIONAL REQUIREMENTS

The present state of the technology seems to make it possible to implement different driver training applications with a growing level of complexity and fidelity to real driving conditions. Nevertheless, there is a lack of common technical specifications both at national and European level.

Technical specifications are needed that define the minimum conditions that a simulator should have to be suitable for use in the different levels of driver training applications.

Functional specifications need to cover the main components of driving simulators: vehicle model, visuals, motion, traffic model and scenarios and instruction.

5.1 Vehicle model, visuals and motion

The simulation of a vehicle dynamics is complex due to the frequency of occurrence of the phases of acceleration and deceleration. An additional difficulty results from the contact of the tyre with the pavement and the resulting effects (inertias connected to the mass of the vehicle but also high frequencies connected to the characteristics of the road).

At present it is not possible to render vehicle dynamics with realism. The design of simulators thus leans on the use of tricks to produce the embedding and the carrying of compromise to guarantee coherence of the produced sensations.

The question of the validity of the results acquired on a driving simulator is crucial for the use of simulators both in behavioural studies and in driver training [Espié, Gauriat and Duraz, 2005].

There are two approaches to validation of driving simulators:

1. Intrinsic validation: Because of the impossibility to render the totality of the dynamics, transfer functions are used. According to this approach the simulator is valid if, for example, the accelerations caused by a given action correspond to those experimented in the actual world.

2. Validation by objective. The question here is to verify the relevance of the tool for a particular usage (study of the driver's behaviour or training). The object of the study is the human and not the simulator, which is considered here only as a tool.

In driver training applications, the aim is to teach the trainee, or to train or retrain a driver. For these purposes only validation by objective is relevant as a simulator that imitates reality perfectly (high intrinsic validity) may even hamper the learning abilities. The simulator is considered as valid if the experiences are transferred in the actual driving.

At present there is little information available to enable perfect choices between expenditure on a particular motion system instead of on a particular visual system, or even sound and vibration system.

Physical fidelity (realism) and functional fidelity (training effects) are often confounded when the role of simulation in the driver training process is discussed.

Physical fidelity is not a sufficient precondition for optimal training effects. For the training of certain skills (e.g. hazard perception) simulations with lower fidelity (e.g. video scenes) can be efficient training tools.

There is, as yet, no distinction between full mission and part-task simulators, nor acknowledgement that realism (isomorphism with real road training) may not be necessary or even desirable in all circumstances.

Similar arguments might surround the fidelity of visual databases. The simple view is that they need to be as realistic as possible.

However, from a training perspective that may not be correct. There may be value in taking unimportant elements out of a visual scene, allowing the driver to concentrate on elements salient to the training objective without distraction.

For example, if a simulation is able to provide a highly realistic and complex urban environment and a busy traffic situation this may be a highly impressive demonstration if the state of the art of the simulation industry, but may force the driver to attend to elements peripheral to the current training objective. If the driver is supposed to focus on responding to a particular signal in the scene, a complex environment may present a number of competing signals and it would be difficult for the trainer to be certain which prompted the response by the driver. Taking extraneous noise away from the scene (removing competing signals) would allow the particular behaviour or skill to be developed effectively and efficiently. The skill can then be later validated in a more complex and realistic environment, whether that is in a simulator on the real road.

Williges et al [1973] proposed the notion of *essential realism*, relating not to what might be regarded as essential for improved face validity, but instead, essential to the particular training requirements under consideration. There are three important elements that should drive decisions on simulation provision within the training process:

- The efficiency and acceptability of the learning in the simulator
- The transfer of the learning to the real world
- The retention of skills or knowledge learned.

Lee [2004] posed a number of interesting questions about simulator development and concluded that the pursuit of higher levels of fidelity in simulation may not be adequate, or even desirable. The reasons being that increased fidelity can undermine scenario control, limit data collection, dilute training potential, and increase likelihood of causing simulator sickness.

5.2 Traffic model

To be acceptable, computer generated traffic has to accurately reproduce driving behaviour at the control, the manoeuvring and the strategic level. This implies that each simulated car has its own vehicle model, perception and control model, and decision logic. There are many different traffic models currently in use. Some merely present a car moving over a track, with hardly any interaction. Others are fully interactive and scriptable, and can handle complex situations on multi-lane intersections and roundabouts. At close observation, however, flaws exist in these models: physical behaviour is not correct, vehicles are not steered the way a driver normally would, manoeuvres are initiated inappropriately, and decision making is not very 'intelligent'. Such erratic behaviour is often observed in traffic situations that cannot be handled by obeying the rules of traffic, such as when four vehicles arrive at the same time at an intersection.

In training applications, an additional requirement emerges. When a particular traffic situation is being imposed (for example overtaking with a complex interaction with three or more vehicles), simulation has to combine vehicles with a correct behaviour, with others with speed and position constraints in order to create a conflicting situation. This combination of autonomous and controlled vehicles in traffic models is not yet solved.

Current simulation technologies do not offer sufficient possibilities to simulate the crucial role of communication between road users.

Traffic / driver models are required that allow to simulate interactions between traffic participants.

5.3 Scenarios and instruction

The simulator based training scenarios and instruction program should provide:

- ***A valid environment to practice the necessary skills.***
- ***Clear goals and contents for training.***
- ***Enough feedback to improve behaviour and to learn.***
- ***A possibility to gain enough experience.***
- ***A learning period long enough to commit the skills and knowledge learned to memory, and a learning climate favourable for safety.***

REFERENCES

Barnard, Y. (2006): *Didactical and pedagogical aspects of e-learning tools*. Proceedings of the Conference on European guidelines for the application of new technologies for driver training and education. Humanist NoE, Madrid,

Clarke, D.D., Ward, P. & Truman, W. (2005): *Voluntary Risk Taking and Skill Deficits in Young Driver Accidents in the UK*. 37:3 Accident Analysis and Prevention 523-529.

Deery, H. (1999): *Hazard and Risk Perception Among Young Novice Drivers*, Journal of Safety Research,Vol 30, No 4

Dolan, D.M., Rupp, D.A., Allen, J.R., Strayer, D.L. and Drews, F.A. (2003): *Simulator training improves driver efficiency: transfer from simulator to real world*. Proceedings of Second International Driving Symposium on Human Factors in Driver Assessment, Training and Vehicle design, Park City, Utah, USA.

Dols, J., Pardo, J., Falkmer, T., Foerst, R. (2001): *The TRAINER PROJECT : A new concept for novice drivers training simulator* - Driving Simulation Conference DSC2000 Paris

Duraz, M. and Espié, S. (2005): T*echniques of validation for driver's training using a driving simulator*. HUMANIST TFG Workshop on the Application of new technologies to driver training. Brno, Czech Republic

Duraz, M. and Espié, S. (2006) *Validation of driving simulators for training*. Proceedings of the Conference on European guidelines for the application of new technologies for driver training and education. Humanist NoE, Madrid

Espié, S., Gauriat P., Duraz M. (2005): *Driving simulators validation: the issue of transferability of results acquired on simulator*. HUMANIST TFG Workshop on the Application of new technologies to driver training. Brno, Czech Republic

Espié, S. (2006): *Training novice driver: toward cognitive training*. Proceedings of the Conference on European guidelines for the application of new technologies for driver training and education. Humanist NoE, Madrid

Falkmer, T. and Gregersen, N.P. (2003): *The TRAINER Project- The Evaluation of a New Simulator-Based Driver Training Methodology*. In: Dorn, L. (red.), Driver Behaviour and Training, proceedings of the 1st international conference on driver behaviour and training, Stratford-upon-Avon, England, p. 317-330.

Falkmer, T. (2005): *Driver education by simulation and assessment of fitness to drive for learner drivers and people with disabilities*. HUMANIST TFG Workshop on the Application of new technologies to driver training. Brno, Czech Republic

Groeger, J.A. (2000): *Understanding Driving-Applying cognitive psychology to a complex everyday task*. Psychology Press Ltd. Hove.

Groot, H.A.M, Vandenberge, D., Van Aerschot, Bekiaris, E. (1999): *Survey of Existing training methodologies and driver instructors' needs*. TRAINER, Del.1.2.

Hanzlíková, I. (2006): *Pedagogic aspects of simulator training process*. Proceedings of the Conference on European guidelines for the application of new technologies for driver training and education. Humanist NoE, Madrid.

Hattaka, M., Keskinen, E., Gregersen, N., Glad, A., Hernetkoski, K. (1999): *Results of EU- Project GADGET*, WP3.

Kammler, K and Schlemmer, K. (2006):: *Computer based training in driving education and current developments on computer assisted driving tests in Europe and in the world*. Proceedings of the Conference on European guidelines for the application of new technologies for driver training and education. Humanist NoE, Madrid.

Kappé, B. (2005) *Driving simulators for driver training: state of the art*. HUMANIST TFG Workshop on the Application of new technologies to driver training. Brno, Czech Republic

Kappé,B. et al (2005): *Virtual instruction in driving simulators*. HUMANIST TFG Workshop on the Application of new technologies to driver training. Brno, Czech Republic

Kemeny, A., Panerai, F. (2003): *Evaluation perception in driving simulation experiments*. Trends in Cognitive Sciences, 7(1):31-376.

Keskinen, E. (1996): *Why do young drivers have more accidents?*. Referate der Esten Interdiziplinären Fachkonferenz 12-14. Berichte der Bundesanstalt fur Strassenwesen. Mensch und Sicherheit, Heft M 52.

Lee (2004): *How low can you go?* Proceedings of Human Factors and Ergonomics Society Conference, New Orleans (CD)

Littig, P., Attwell, G., Holmfeld, L., Fabian, P., Karpati, A. (2003): *E-learning in Europe – Results and Recoomendations*, in Impuls 10.

Michon, J.A. (1985): *A critical view of driver behavior models: what do we know, what should we do?* In: Evans, L. and Schwing, R. (Eds.) Human Behavior and Traffic Safety. Plenum Press, New York.

Michon, J. A. (1989): *Explanatory Pitfalls and Rule-Based Driver Models*. Accident Analysis and Prevention, Vol 21, 341-353.

Najjir, L.J. (1995) *Does multimedia information help people learn*. Technical Report GIT-GVU-95-28.

Pardillo et.al. (2005): *Functional requirements of driver training and education tools, identification of research needs and potential applications of e-learning* GUPM-041018T1051220T1-DA Humanist deliverable G3 Humanist NoE, Lyon

Pardillo, J. M., Camarero A., Madrigal, E. and Bojorquez R. (2005): *State of the art in Driving Simulators: Results of the Humanist Driving Simulators Inventory*. HUMANIST TFG Workshop on the Application of new technologies to driver training. Brno, Czech Republic

Parkes, A.M., (2003): *Truck driver training using simulation in England*. In J. D. Lee, M. Rizzo & D. V. McGehee (Eds.), Proceedings of the Second International Driving Symposium on Human Factors in Driver Assessment, Training, and Vehicle Design. Iowa City: University of Iowa. pp. 59-63.

Parkes, A.M. and Rau, J. (2004): *An evaluation of simulation as a viable tool for truck driver training*. ITEC 2004, London (in press):

Parkes, A.M. (2005): *Improved realism and improved utility of driving simulators: are they mutually exclusive?*. HUMANIST TFG Workshop on the Application of new technologies to driver training. Brno, Czech Republic):

Prücher, F. (2006): *Computer based training in driving education and current developments on a computer assisted driving test in Germany*. Proceedings of the Conference on European guidelines for the application of new technologies for driver training and education. Humanist NoE, Madrid.

Renge, K. (2000). *Effect of Driving Experience on Drivers' Decoding Process of Roadway*. Interpersonal Communication; 43:1 Ergonomics 27-39.

Rizzo, M., Severson, J., Cremer, J., & Price, K. (2002): *An abstract virtual environment tool to assess decision-making in impaired drivers*. In J. D. Lee, M. Rizzo & D. V. McGehee (Eds.), Proceedings of the Second International Driving Symposium on Human Factors in Driver Assessment, Training, and Vehicle Design. Iowa City: University of Iowa

Trogaluer, T. (2005): *State of the art on e-learning applications Results of survey of e-learning*. HUMANIST TFG Workshop on the Application of new technologies to driver training. Brno, Czech Republic.

Turetschek, C. (2006): *Potentials and Risks of New Technologies in the Training of young drivers*. Proceedings of the Conference on European guidelines for the application of new technologies for driver training and education. Humanist NoE, Madrid, 2006

Underwood, G, Crundall, D. & Chapman, P. (2002). *Selective Searching While Driving: The Role Of Experience*. In Hazard Detection And General Surveillance. 45:1 Ergonomics 1-12.

Vlakveld, W.P. (2005): *The use of simulators in basic driver training*. HUMANIST TFG Workshop on the Application of new technologies to driver training. Brno, Czech Republic.

Vlakveld, W. (2006) *What does educational psychology tells us and what are the implications for simulator training?*. Proceedings of the Conference on European guidelines for the application of new technologies for driver training and education. Humanist NoE, Madrid, 2006

Welles, R.T. and Holdsworth, M. (2000): *Tactical driver training using simulation*. I/ITSEC 200 Conference. Nov. 30th. 2000. Orlando, Florida, USA.

Widlroither, H., et al (2003): *On designing automotive HMIs for elderly drivers: the AGILE initiative*. 10th HCI conference, Crete, Greece, June 2003

Williges, B.H., Roscoe, S.N., and Williges, R.C. (1973): *Synthetic flight training revisited*. Human Factors, 15, 543-560.