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Save Money. Prevent.

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Abstract

At its core, being a road user means solving constant new driving tasks in constantly changing contexts; as a form of social behavior, it extends beyond motor vehicle operation. The driver's freedom of action means that his or her attitude, behavior and motivation are given special importance. For this reason, targeted training procedures are used to improve traffic safety. In this respect, thanks to rapidly advancing technological developments, driving simulators offer interesting possible applications, and, furthermore, advantages in terms of objectification, documentation, data capture and evaluation. As there are hardly any risks or dangers, however, the use of driving simulators requires specific training concepts which are based on an analysis of tasks, activities and boundary conditions, and which allocate other training media their place in an overall training system.

This manual brings together the basic principles of education and training, modeling, task description and analysis, and the pros and cons of simulation as a training method. It describes the method used to design appropriate teaching and training programs. The main components and a taxonomy of the simulator technology are presented. As an example, an interlinked driving teaching program which has been carried out is presented, with vehicles and simulators for professional drivers. This is followed by three advanced training programs which have also been tested. These simulator training courses for professional hazardous materials and package goods drivers are based on optimized simulator-specific teaching and training matter, covering an economic driving technique, an anticipatory driving technique including rare events and a frustration-resistant driving technique, i.e. self-control. The manual is rounded off by descriptions of scripts, learning strands, measurement values, questionnaires and analysis procedures to assess training success. Organizational forms, business management calculations and staff selection processes are suggested for the actual running of simulators. These are complemented by easy-to-understand profiles and instructions for "train the trainer" courses.

Preface

A good decade after the temporary end of attempts to make driving simulation into an accepted, productive teaching and training technology, new possibilities and chances are on the horizon, motivated by current EU legislation. The author has been involved, in terms of technology and content, in the development of driving simulators and has tracked their progress. This book attempts to take driving simulation seriously as a technology for teaching and training, to demonstrate possible paths for future development and to promote the formation of a community as a basis for future success.

The author would like to thank all the institutions, companies and universities involved for providing him with material, and for their constant willingness to discuss matters. Special thanks go to Prof. R. Bernotat and the Research Establishment for Applied Sciences (Forschungsgesellschaft für Angewandte Naturwissenschaften e.V.) in Wachtberg, Prof. H.-P. Willumeit and Berlin University of Technology, and all staff and students, for the years of factual, financial, technological and personal support. On behalf of the above I would like to thank the translator, Anne Koth.

Although the masculine gender has been chosen in the text for convenience, the information applies equally to the feminine gender.

Contents

Chapter 1
Introduction: Demand and Reality

A wide range of educational and training sectors use simulations, and their technical offshoots, simulators, e.g. flight simulators to train pilots, or ship simulators to train captains. Even rail companies use railway simulators. Driving simulators are not used to the same extent. Some large-scale projects can be found internationally, e.g. in the USA or in Germany and France, and there are a range of driving schools which use small driving simulators – usually, and tellingly, technically reworked games simulators. However, there are no defining lines to say what a driving simulator is, or what one needs to do in terms of technology and content for a device to count as one. There are also no major common policy decisions. The best model for successfully creating these defining lines is the driving simulator's greatest competitor, the car itself.

A glance at the technological genesis of the automotive industry shows that major, early policy decisions contributed to its success. As early as the start of the twentieth century, the groups concerned agreed on the specifications required by a piece of technology to be called an "automobile": A car has four wheels and a piston engine, has space for four people and their luggage, and drives as fast as possible. Its aim was also defined and accepted: The automobile should cross fairly large distances quickly and comfortably. At the time, it was known in German as a "Rennreise-Limousine" (long-distance racing sedan), as Knie (1994) described very well.

In the case of simulators, the reasons no policy decisions have been made, and no defining lines drawn up, are easy to find. Unlike flying, driving a car is a highly dynamic affair. Drivers are only a few meters away from objects they pass at a comparatively high speed. From the observer's point of view, relatively high angular velocities are reached. Furthermore, the social traffic environment, especially in towns, stands out for the exceptionally high number of objects and people, also moving. The course of the vehicle's movement involves high accelerations and frequencies, whether during braking or in curves. One result of this is that "road testing" has become established as a teaching department at well-known universities. There are also extensive DIN and ISO standards on how to carry one out – another indication that the process has been successful, policy decisions drawn up and defining lines set down: a typical task for standardization committees. This has not occurred in driving simulation.

As well as the technological specifications, there are also boundary conditions. One characteristic of driving is the driver's extensive freedom to act and make decisions; this is brought into play as an advertising ploy, with good reason considering the context. However, unlike flight simulation, where pilots work through preset action routines, outside critical situations, it is precisely this "freedom" which places high demands on "valid" learning strands in driving simulators. For students to get a reasonably realistic experience of driving, the learning strands (here: vocationally oriented thematic units) must create an almost infinite range and quantity of situational variables unknown to the students.

On top of this, of course, comes the price. A simple driving simulator without this necessary variety of learning strands costs at least as much as the vehicle simulated. High-tech driving simulators to train hazardous materials drivers cost many times as much, even ten times as much, as the tractor trailers in question. The tractor trailer on the road, with an expert driving instructor, also means the learning strand can be varied in a way the simulator can hardly equal, even when all technological possibilities are put to use. Flight simulators do not have this problem; quite the reverse: A flight simulator lesson generally costs only one tenth of an actual flight lesson.

However, the reasons listed above are not the only cause for the failure of driving simulation as a training method. A glance at the technological genesis of driving simulation shows that the wide community of engineers, psychologists, sociologists, economists, politicians, ecologists, associations, academies and universities involved have not managed to make the necessary policy decisions and create wide-scope definitions. There is no explanation of what driving simulators actually are, technologically: Both a multimillion-dollar high-tech device and a control unit with a steering wheel and a monitor are called driving simulators.

More serious, however, are the problems which occur due to the lack of wide-scope definitions for the aim, use and purpose of driving simulators. Is it for demonstration, to satisfy people's urge to play games, to replace a vehicle, for research, risk training, education, continued education or in lieu of a driving school?

1.1 The Technological Genesis of Driving Simulation

The technological genesis of the automobile demonstrates the advantages of making policy decisions early. Such decisions were made within the community, despite all the competition there, and, incredibly, still firmly apply today, more than 100 years after they were first introduced. For example, Knie (1994) believes this accounts for the success of the diesel engine, which is a piston engine, the basis for which was laid down in the form of policy decisions by MAN and others as early as 1910. It also accounts, he believes, for the failure of the NSU/Wankel project (not a piston engine), which may also have been affected by a lack of industry interest or subtle sabotage.

Of course, early policy decisions of this kind also have disadvantages, as we see today; however, they are essential for the success of any new technology. They are the only way the policy-making process can set in and the transition to the actual use of the technology can take place. This use must be recognized and the construction of the technology must be tested. To safeguard the preliminary work, it must be firmly embedded in an overall political strategy. A carefully assembled body of knowledge means that definitions can be created collectively. Appropriate supplementary research must be carried out for technological and academic validation. The technological structure must be set down using a formal and informal set of rules.

This manual takes up this point. It provides basic principles for the policy decisions required within the "driving simulation" community, which have yet to take shape and depend on the demands of the sector. These policy decisions are overdue, especially in view of current EU laws on driver training; after all, simulators open up whole new avenues for training. The aim is to shift about 50 percent of practical training for the truck driver's license from the road to simulation. The German Road Safety Council, Deutscher Verkehrssicherheitsrat e.V., currently supplements its safety training courses with simulator components, see Käppler (2000). German transport companies are supplementing their rail and tram driver training courses with simulators.

Driving schools and other commercial providers offer special simulator-assisted training programs for professional drivers, dealing with efficient, safe driving. International teams are developing basic principles for understanding human error. This book sums up all the findings from this work on training measures and criteria to evaluate the success of training courses. In this sense, it can be seen as a basis for discussion on decisions to be made, and is not only aimed at specialists. As well as the introduction, it is divided into six chapters with the following contents:

- Drivers, Vehicles and Errors
- Creating Models, Teaching, Training and Simulators
- Smart Truck Driver Education Program
- Smart Hazardous Goods Driver Training Program.

Chapter 2 describes the nature of the issue, including the basic principles of motor vehicle operation and human error, from the point of view of traffic safety policy, i.e. *Model Creation, Teaching &, Training with Simulators* with training course design, aims, concepts and the media. A taxonomy classifying driving simulators is presented, and the validity of results obtained with simulators is discussed in detail. Chapter 3 presents a concept for simulator-assisted *truck driver training*. Chapter 4 is another example of use in action and presents the conceptual design and contents of the Advanced Driver Course for an efficient, anticipatory driving technique by hazardous materials drivers. It includes a training schedule, questionnaires, briefings and replays, and notes on trainers' qualifications. Chapter 5 contains *Concluding Remarks* and Chap. 6 the *Bibliography*.

Text boxes explain major terms for a better understanding of the issue.

Chapter 2
Teaching and Training with Simulators

2.1 Drivers, Vehicles and Errors

Traffic systems are very different human/machine systems for monitoring and controlling very different information and deployment processes. The ergonomic view of this type of complex system is user-oriented and starts out with tasks and activities. The classic understanding of motor vehicle operation sees it as a constant or discrete closed-loop system involving the driver, the vehicle, the environment, and sees traffic as moving objects by mechanical means in order to cover spatial distances. The task of driving itself has been broken down into subtasks and given a hierarchical structure (Rößger et al., 1962; Käppler & Bernotat, 1985; Johannsen, 1990), see Fig. 2.1.

On the navigation level, a roadway is selected from the traffic network. On the road guidance or handling level, the lead dimensions of course and speed are adjusted with respect to the current traffic situation, taking into account the traffic rules (e.g. overtaking maneuvers). Stabilization means operating the vehicle on the street itself even in the presence of disruptions (e.g. crosswinds) and monitoring course and speed. Differences between intended and actual variables are minimized. A driver will perceive relevant information, plan any minimization at the cognition level and act. Rasmussen (1983) drew attention to differences between the task and its actual implementation. He dealt with actual activities and disassembled them into:

- Skill-based action
- Rule-based action
- Knowledge-based action.

Skill-based action takes place without deliberate attention. It is not possible to say what information it is based on. Some examples are simple driving operations such as changing gear. In the case of rule-based action, a situation is diagnosed by recognizing a combination of symptoms. Every situation is tied together with if-then-else rules and certain actions are associated. Some examples are the application of traffic rules, overtaking or critical driving situations. Knowledge-based action

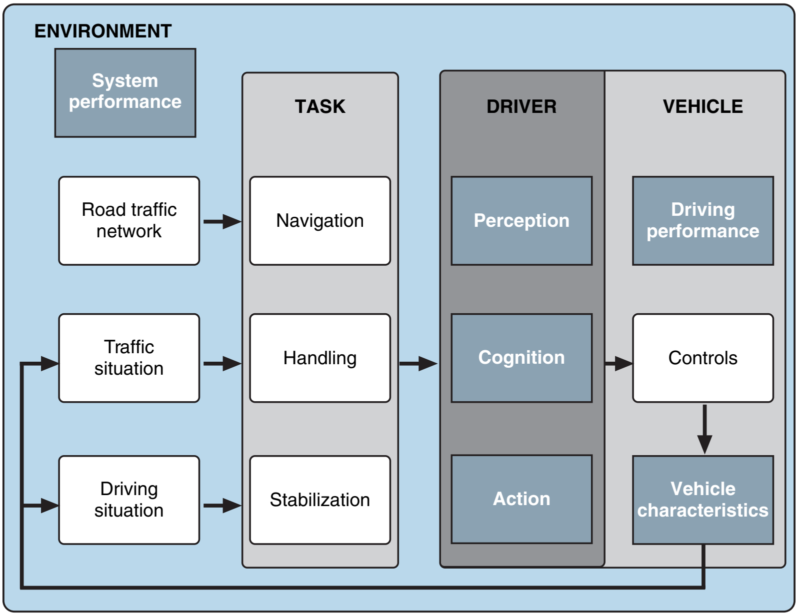

Fig. 2.1 Closed-Loop System of Driver, Vehicle, Environment (Käppler, 1993c)

includes the deliberate formulation of goals plus the design, analysis and choice of action plans. One example is searching for a route in an unfamiliar area.

The overlaps between the tasks in Fig. 2.1 and these action levels are fluent. Each subtask (navigation, road guidance and stabilization) can be processed at a skill-based, rule-based or knowledge-based level. For example, an unskilled driver masters the stabilization of the vehicle with deliberate attention, i.e. knowledge-based, if he is inexperienced or if vehicle handling characteristics are problematic. However, even this representation is not yet complete. Looking at all motoring activities shows that drivers, like other operators, actually do much more than conventional models suppose. They collect and judge a lot of information about different planning levels in order to plan and implement transports. This may be classified as follows:

- Determination: "What is the situation like?"
- Assessment and decision: "What does this mean and should I act?"
- Planning action: "How shall I act?"
- Carrying out the action: "I act."
- Checking: "Was I successful?"

Alongside technical problems which are of no further interest here, a range of disruptions can occur, such as:

- incomplete information for any assessment
- large number of steps, apparently of equal merit