Intelligent Vehicle Safety Systems

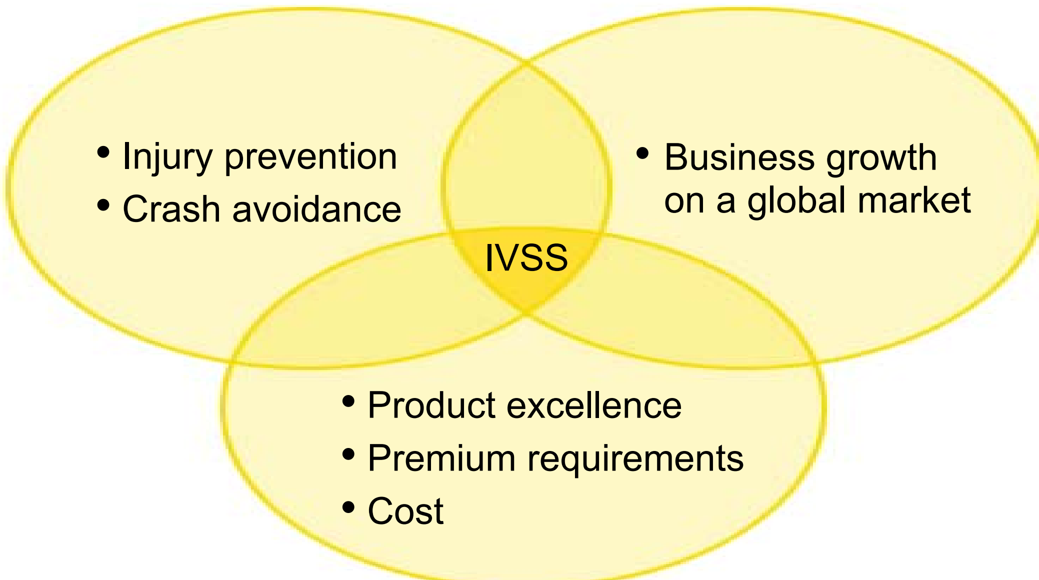
Dialog Management system

IVSS Project Report

The IVSS Programme

The IVSS programme was set up to stimulate research and development for the road safety of the future. The end result will probably be new, smart technologies and new IT systems that will help reduce the number of traffic-related fatalities and serious injuries.

IVSS projects shall meet the following three criteria: road safety, economic growth and commercially marketable technical systems.



Three interacting components - for better safety, growth and competitiveness:

The human being

Preventive solutions based on the vehicle’s most important component.

The road

Intelligent systems designed to increase security for all road users.

The vehicle

Active safety through pro-active technology.

Title of the report: Dialog Management System

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Summary

In order to drive safely the driver has to keep a continuous attention to the road. It is also known that humans have difficulties in keeping attention up for long periods and that distraction and fatigue are known phenomena.

Driver distraction is today in focus in development of transport systems, especially when considering the introduction of the amount of communication- , entertainment- and support systems in vehicles. Here it is important that the use of this equipment does not get in conflict with the primary driving task, putting the driving safety on hazard. To solve this conflict situation it is necessary to adopt the information flow, to- and from these systems, to the actual driving situation. By estimating and/or by measuring the actual driving situation and the driver's actions and status, the interaction with secondary functions can be scheduled so that they will not overload the driver.

A Dialog Management system was developed and tested in a driving simulator at Linköping university. This was done by applying the methodology "Simulator Based Design". A special Tool – the DM Tool was developed in order to easily change the way the workload estimation was done and the behaviour of the dialog management.

Tests were done where 18 test subjects drove with- and without the Dialog Management system. The scenario contained five critical scenarios; radio operation in a roundabout, enter a road while presenting a warning message, call David S. from phone book, answer a phone call in a restriction area and answer a phone call in a restriction area and while a skate board crossed the street.

Both objective and subjective measures were adapted for use in the simulator. The result is mostly positive for the Dialog Management system regarding driver performance and acceptance. The project work also brought a lot of learning on how to work practically with the "Simulator Based Design" method, especially when it comes to development and use of virtual prototypes, design of experiments and measurement.

Sammanfattning

För säker körning måste förarens uppmärksamhet kontinuerligt vara riktad på köruppgiften. Dock är det känt att människor har svårt att upprätthålla uppmärksamhet under längre perioder, distraktion och trötthet är här kända fenomen.

Förardistraktion har fått ett ökat fokus i dagens transportsystemutveckling, speciellt med hänsyn till att förarmiljön i moderna fordon får fler och fler stöd-, nöjes- och informationssystem. Det är då viktigt att användandet av dessa inte inverkar negativt på förarens körförmåga och därmed trafiksäkerheten. För att inte negativt påverka körsäkerheten är det nödvändigt att kunna anpassa informationsflödet, till och från ”intelligenta” hjälpsystem mm, till den aktuella körsituationen. Genom att estimera och/eller mäta körsituationen samt förarens aktiviteter och status, kan därmed interaktionen med sekundära funktioner schemaläggas så att de inte överbelastar föraren.

Utveckling av ett sådant dialohanteringssystem gjordes i körsimulatorn på Linköpings universitet, där metodiken ”Simulator Based Design” användes. För att kunna utvecka funktionaliteten i dialoghanteraren utvecklades ett verktyg – ”DM Tool”. Med detta verktyg är det enkelt att modifiera beräkningen av arbetsbelastning samt beteendet på dialoghanteringen.

Tester utfördes med 18 förare som körde både med- och utan dialoghanteringssystem. Scenariet innehöll fem kritiska körsituationer; dålig radiomottagning i en rondell, varningsmeddelande i en korsning, ringa ett telefonsamtal i en rondell, svara på inkommande telefonsamtal i ett 30 km/h område samt svara på inkommande telefonsamtal i ett 30 km/h område samtidigt som en skateboardåkare korsar vägen.

Objektiva- och subjektiva mätmetoder anpassades för simulatorbruk. Resultatet var övervägande positivt för dialoghantering vad gäller körprestation och acceptans. Projektet tillförde också många lärdomar om praktiskt arbete inom metodiken ”Simulator Based Design”, speciellt vad gäller framtagning och användande av virtuella prototyper, design av experiment och mätmetodik.

1. Introduction.

To drive and operate the systems in a vehicle has become more and more complex. Vehicles today have more controls and display more information than just for some decade ago. This trend seems to continue, which means we have to face an even more complex driver environment in the future.

Saab has a long tradition of preventing driver distraction in cars. In 1994 a “manual” workload estimator was introduced (Saab 900). By a press of a button (Black Panel) all displays were blacked out except for the speedometer. In 1998 the first dynamic workload estimator was introduced (Saab 9-5). In driving situations where high driving workload are expected, information of less safety importance will be suppressed. The input data to the workload estimation derives from actuators and sensors in the vehicles information system. For example; if the turn indicator is on (driver intends to turn or overtake) or the brakes are engaged (driver intends to stop) the workload is expected to be high. (Patent in Sweden and Germany). In 2002 (Saab 9-3) the dialog manager was further developed and used for managing both input- and output of information. If driving workload is high, input operations requiring too much of the drivers attention, can be locked out. (Example 1: Incoming telephone calls will be stopped. Example 2: Keyboard entries of telephone numbers, destination address etc. can be locked out.)

Project Partners:

Saab Automobile AB (project leader), vehicle manufacturer.

ACE Simulation AB, provider of real time simulation systems and vehicle technology.

Linköpings universitet IKP (LiU), research in Human-Machine interaction.

2. Project objectives and purpose of Workload Estimation and Dialog Management.

The objective of this project was to further develop the concepts of workload estimation and dialog management to become more accurate and adopted to future vehicle functions. It will also take advantage of new technologies available.

The purpose of the workload estimation and dialog management is to eliminate or suspend potentially distracting information in high workload situations. The function of a dialog manager should in such a case schedule secondary tasks to avoid conflicts with primary driving tasks. The dialog manager should also enable safe and effective use of communication- ,entertainment- and information systems.

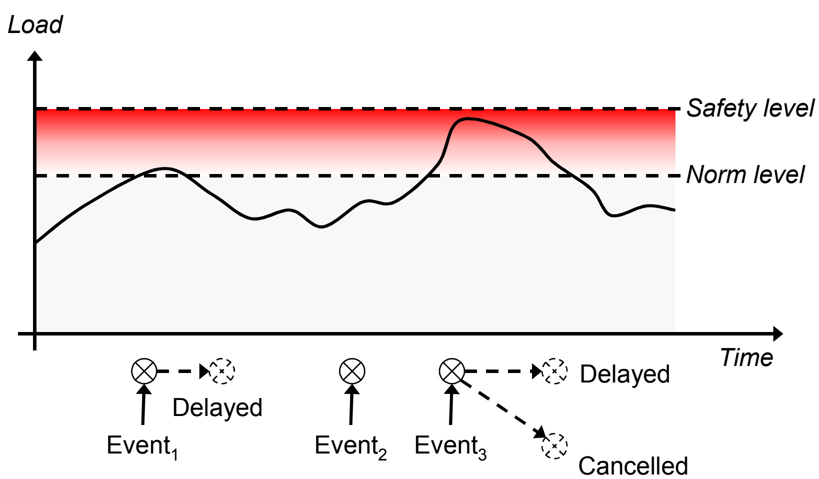

Figure 1. Potentially distracting events may be delayed or cancelled in high workload situations.

In order to test and evaluate such a function the following work was developed:

- A dialog management function
- A Dialog management Tool in which the function is realized and tested
- A virtual environment where tests took place
- A test scenario realised in virtual environment
- Test methods

The effectiveness of the workload estimation and dialog management was developed, tested and evaluated by using virtual prototyping tools and a driving simulator.

3. Dialog manager function.

The dialog management function can be seen as a coordinator of both in-vehicle information streams and vehicle input/output-functions. The main purpose of this function is to regulate the driver-vehicle interaction in real-time depending on the actual situation, given a specific context. One of the main control conditions in this coordinating activity is an estimate of the driver workload. The main idea of a driver-vehicle interaction management function is to eliminate or suspend potential distractions from the primary driving task in high workload situations. Saab provided one driver workload estimation algorithm that were used in the project.

The workload estimation algorithm consisted of 5 states with sub-states ranging from a state called stand-still to Driving task extra demanding. In each of these states the type of load (cognitive/motoric/visual) was described.

In the lower states (standing still and “normal” driving) the radio, settings, navigation etc. could be manipulated. Warnings, check messages and phone calls were allowed to break through. The infotainment system was not affected; nothing was delayed or locked-out.

When the driver was driving through restriction areas, near schools, hospital areas etc, several functions were locked-out or delayed. (The visual load is particularly high when driving through a restriction area.) The driver was therefore not allowed to manipulate the infotainment system in this state. To support the visual task even more the vehicle speed was given to the driver via the auditory channel, allowing even more visual attention on the road scenery.

When the driver had an extra demanding task, as in a roundabout, during a take-over, or close to a turn, the access to the infotainment systems was limited. Warnings, check messages and phone calls were delayed in order to help the driver focus on the primary driving task. Warning messages with high priority were allowed to break through (e.g. Brake fluid level low).

4. The DM Tool.

The dialog management prototyping tool, called the DM Tool, developed by ACE Simulation holds two main functions,

- Container of a custom driver workload algorithm
- Customizable rule-based coordinator function for dialog management prototyping

The tool supports monitoring and control of these two DM-parts. The driver workload algorithm with related coordination function were implemented for evaluation.

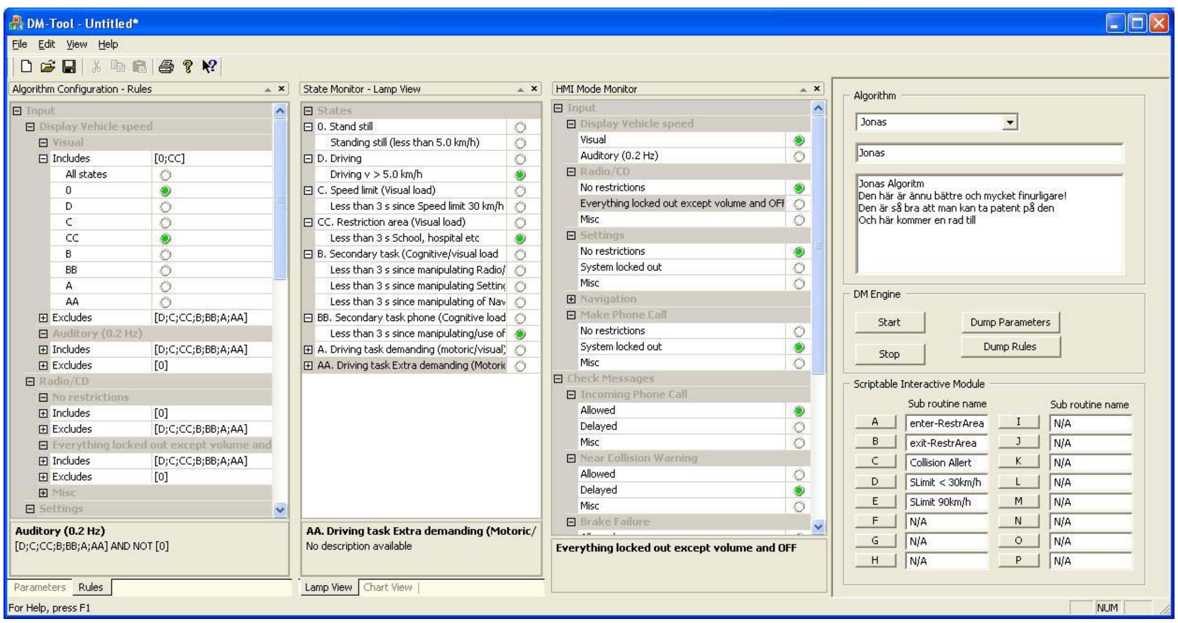

Figure 2. A screen shot of the DM Tool.

5. The virtual Test Environment

Car cockpit

The cockpit at the LiU simulator is a converted (for simulator use) Saab 9-3 cab. The center consol functions were realized through a touch screen solution, the main instrumentation hardware was replaced by a screen-based application, while all other input functions (steering-wheel, buttons, pedals, etc.) were intact and coupled to the simulator software. Also the ordinary audio system was used except for the radio panel, which was an application running at the touch screen. The panel was controllable in the same way as the ordinary radio equipment in Saab 9-3.

Environment model

LiU produced a conceptual description on the driving environment and the specific events that should be introduced in order to challenge the DM system under evaluation. This document also included the measures used for the evaluation part in the project. The driving environment model (road network) was produced by ACE. Saab contributed with environmental objects (houses) from a previous project (a virtual city model of Trollhättan). Special environmental features were added to meet the specific demands of the DM project. The features introduced were one hospital area and one school area, both with 30 kilometers/hour speed restriction, two large roundabouts, and a rural road for driver training before entering the city area.

Driving scenario

The driving scenario consisted of a planned ownship route, guided by an audio-based navigation system supplemented by arrows visible at the center consol display in the cockpit. Traffic streams with different features were started at different stages during the route. This was achieved by placing virtual actuators along the route triggered by the ownship passage. Also virtual persons with different activities and some other disturbing events were triggered in the same way.

Figure 3. The Saab cockpit and the visual scene in the Driving simulator at Linköping University.

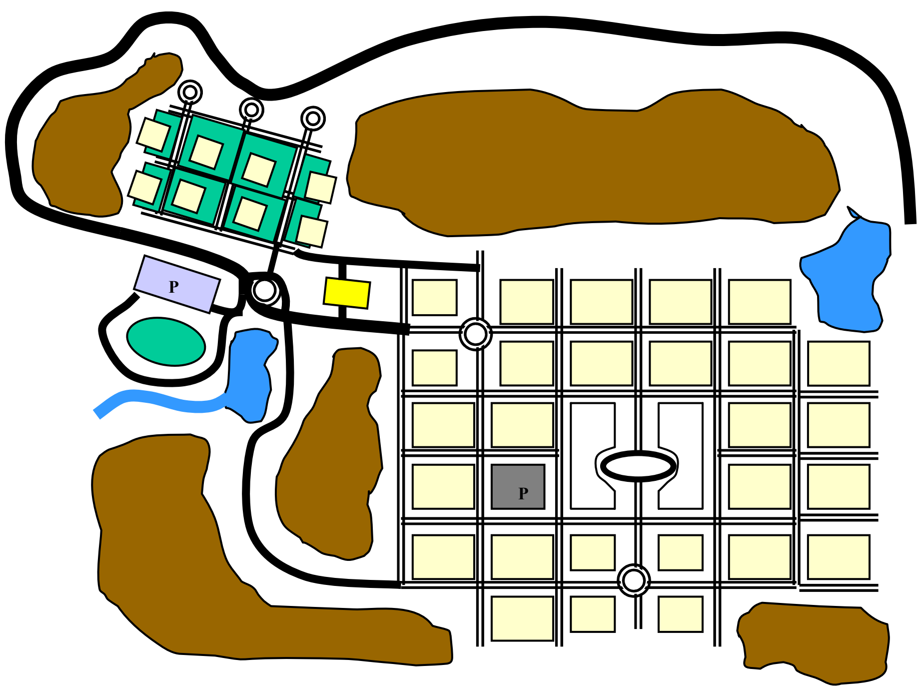

Figure 4. A map of the virtual environment built for the tests.

6. The methodology used to design technical concepts and test scenario.

Dialogue Management (DM) systems are by nature very complex, since they are supposed to manage different functions in the driver interface in real-time depending on the current situation. In more advanced system solutions the range of the system will cover a large set of multi-modal input and output functions in an intelligent and flexible way in order to facilitate the core activity, the driving task.

In developing such complex systems, where the driver is closely involved, human-in-the-loop simulators are almost necessary tools and have to be used in a well-structured procedure. This procedure has been labeled Simulator-Based Design (SBD) and has been further developed through this project. The SBD approach has been in focus for a dissertation at Linköping University by one of the project participants (Torbjörn Alm, LiU). The major input from this project to the thesis is in the event-planning part, where a more ecological approach has been deployed than in commonly reported car simulation activities. This new approach includes a set of measures specifically developed for the different interventions by the DM system in various traffic situations. In most other reported simulations one single measure is used, for example Response Time or Distance to Objects, while the DM system evaluation included multiple measures.

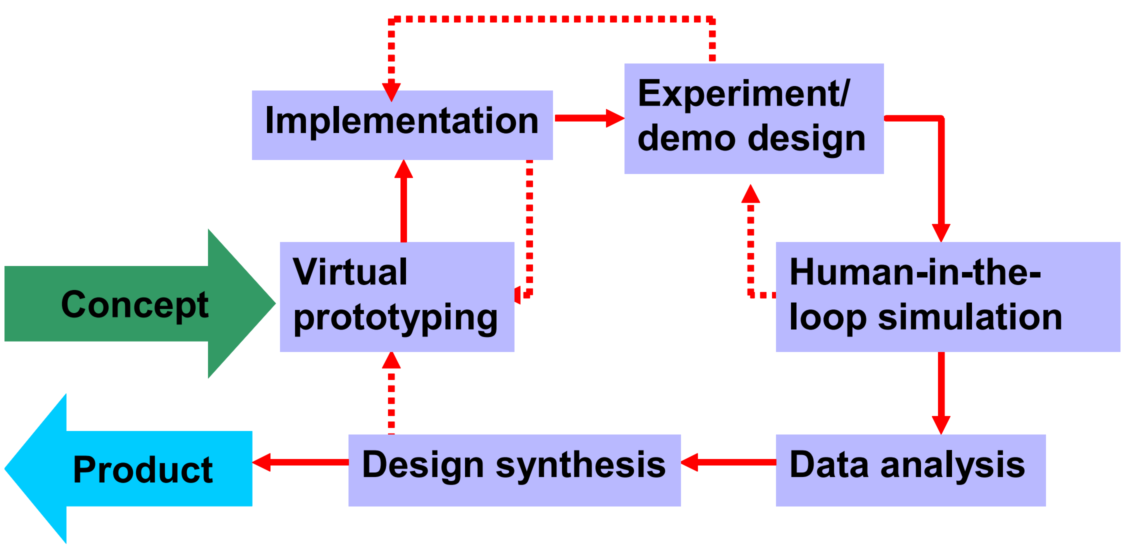

Figure 5. The main steps in the SBD process. The dotted arrows indicate iterations, which is a crucial part of the SBD approach.

The SBD procedure is shown in Figure 5 and this procedure has been utilized in the DM project. One goal, still to be obtained, is to establish this procedure at Saab Automobile.

Referring to the SBD figure, only some of the iterative loops have been possible to carry out within the project limitations. This means that from a product development perspective the process is not finished. However, the steps already taken have brought relevant SBD resources to the project parties, which could be utilized in future DM related activities. Examples of such resources are scenario components, environment model (the city), and measurement design. The deployment of a reuse strategy is also one of the cornerstones in the Simulator-Based Design methodology, which makes the process more cost-effective over time.

7. Test Methodology.

18 participants (11/4 male/female), all students at LiU with driving licenses, were hired (one movie ticket each) for the experiment. The study was designed as a within group experiment with two conditions, with and without the DM system. The order of condition was counter-balanced between subjects to avoid training effects, since the two experimental rounds were equal. Each driving session was carried out in a continuous sequence. After seven experiment sessions we decided to terminate the experiment for a DM system adjustment. The reason for this was that a function, perfectly all right for a sharp system, disturbed the driver's performance during a section of the drive when such disturbance was undesired. The DM system was adjusted and only the measurements from the last eleven participants were included in the later analysis.

In the experiment the participants were exposed to five critical events;

- Radio operation in a roundabout (bad reception – tuning needed).
- Enter a road while presenting ”Washer Fluid level low”.
- Telephone task in a roundabout. (”Call David S. from phone book”)
- Answer incoming phone call in a 30 km/h restriction area.
- Answer incoming phone call in a 30 km/h restriction area and a skateboarder crossing in front.

8. Results and conclusions.

As a concept the Dialog Management system is very advanced, but with the increasing number of computer and communication based systems there will be a need for management systems which could regulate the driver-vehicle interaction in real-time depending on the actual situation, given a specific context.

In this study, however, the system prototype was designed with somewhat lower ambition. The reason for this was partly a production concern (the system was meant to be easily transferred into a product in the near future) and partly a decision with couplings to the limited experience (worldwide) of similar simulator studies. This also triggers the question on the choice of a simulator-based study instead of having a field study with instrumented cars. The short answer is that it should be much more time-consuming to go out in the field and the answers should be much less reliable (except for subjective opinions). The simulation gives all kinds of objective data for completely controlled situations, which also could be compressed in the time dimension, which means that a number of critical events could take place in a very short period of time. In real driving "you have to wait for the moose for years".

The results of the study are mainly positive for the DM concept and the most important features of the DM system were highly appreciated by the participants. The results are also possible to extrapolate to traffic safety. When the driver keep his/her position on the lane in good control, this is good for safety reasons. If the driver can manage tricky traffic situation more effectively, this will have a positive safety impact. If the driver has appropriate oral information in settings where visual alertness is needed, this will enhance situational awareness and thereby traffic safety.

However, maybe the most important results of this study appear in the methodology area. The experience from this project has been utilized in the concept of Simulator-Based Design (SBD), reported at conferences, to some extent included in a master thesis, and further developed in a Ph.D. thesis, which will be defended in the spring 2007. We also believe that this knowledge will be of great importance for industrial application. But on the industrial side it is necessary to get further experience, since the miss-match for the simulator investment in relation to this project made it impossible for Saab to fully make use of this project as a vehicle for knowledge development on the methodology side.

This conclusion combined with the relatively low ambition for the DM system development within the limitations of this project should stimulate all parties involved, including funding parties, to continue this work in the near future. Dialog Management is a great concept with great potential for further development and also with a great potential for having substantial impact on traffic safety. And further development and implementation of the SBD concept will strengthen industrial competitiveness, which is one of the strategic goals for the Swedish IVSS program.

In the future we're looking forward to a more advanced DM system embracing dynamic adaptation to vehicle status, driver status as well as contextual and situational factors. A more advanced system should handle all kind of information, including comfort messages, infotainment, safety critical information, prioritization of warning messages etcetera, utilizing multimodal capabilities according to the nature of the information, driver condition and competence.

The deliverables produced in this project will be used in further activities in this area.

- The DM principles and algorithms will be introduced in future vehicles at General Motors.
- The DM Tool is a part of the ACE simulation software and thus can be used by a broad user group.
- The virtual environment and measurement tools will be used in further work at Linköpings university, where one goal is to increase traffic safety by optimization of Human-Machine Interface.

9. Publications.

Parts of the project work are included in the Ph D dissertation ”Simulator-Based Design: Methodology and vehicle display applications” (T.Alm)

M Sc thesis: “A General Framework for Simulator-based HMI Design in the Development of In-Vehicle Systems” (F. Farcas, S.R. Kommakula)

Scientific publication: “Business Process Reengineering in the Automotive Area by Simulator-Based Design”. Accepterat bokkapitel i “Simulation and Modeling: Current Technologies and Applications”, Idea Group Inc. Hershey, Pa, USA. (T. Alm, J. Alfredson, K. Ohlsson)

Conference contribution: Driving Simulator Conference, North America, 2005: ”Glass Cockpit Simulators – Tools for IT-based Car Systems Design and Evaluation” (T. Alm, R. Kovordanyi, K. Ohlsson)

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