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6th Framework Programme - Priority 2 "Information Society Technologies"
"**HUMAN centred design for Information Society Technologies**"
Proposal n° **507 420**
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Final Reviews of knowledge on Human Centred Design applied to IVIS and ADAS systems

Deliverable 7 of Task Force C

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Deliverable C7 "Final Reviews of knowledge on Human Centred Design applied to IVIS and ADAS systems"								
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1 Summary

This document provides a presentation of the content and conclusions drawn from the HUMANIST workshop held in Vienna on the 18th of September 2007.

2 Introduction

The present deliverable, Deliverable C.7 "Final Reviews of knowledge on Human Centred Design applied to IVIS and ADAS systems" is an extension of the deliverable “Reviews of knowledge on Human Centred Design (HCD) applied to IVIS and ADAS systems”, which was a result of HUMANIST TF C WP C.3 “Development of ergonomic design criteria” work. The complete C.5 deliverable is found in annex 1 to this document. C.5 used a theoretical framework provided by Joint Cognitive model of Driver-Vehicle-Environment (Chapter 2) and a description of User (Human) Centred Design approach (Chapter 4) to try to provide guidelines or code of best practice for use in the user-centred design process of future IVIS and ADAS. Since “Reviews of knowledge on…” was finished, a workshop has been held in Vienna in order to discuss and reflect upon the user centred design process. The workshop covered two days of workshop, presentations and discussion during 18-19 of September 2007. The presentations from the second day can be found in “Report on interest and use of joint-cognitive models for human centred design”, deliverable C.6 from TFC written by Christine Turetschek. In the following, the first day workshop in Vienna is briefly summarized. This constitutes the extension of C.6.

3 Description of the workshop

The workshop that was held on the first day by Selina Mårdh, VTI, started with a brief overview of deliverable 5 of Task Force C “Intermediate reviews of knowledge on Human Centred Design applied to IVIS and ADAS”.

The conclusions of deliverable 5 was that there is no evident answer on how to design and evaluate IVIS and ADAS to ensure usability and safety requirements. More work needs to be done in order to know which method is best suited for what part of the design process.

After the overview, a recently developed method on safety testing and evaluation of IVIS was presented. The method, called SafeTE, was developed by Johan Engström, Volvo Technology and Selina Mårdh, VTI, on assignment of the Swedish Road Administration (Engström and Mårdh, 2007). The slides from the presentation of that study are found in annex 2.

The workshop ended by a discussion on the user-centred design process.

4 Conclusions from the workshop

There was a clear consensus of the fact that it is not possible to identify one single method that covers every possible study design in a user-centred design process. Although a structure for a usable design process was discussed. In the future it would be possible to add methods within each of the stages of the structure. Similar work has been done in other parts of the 6th framework programme.

Proposed structure of a usable design process:

- Idea generation
- Usability planning
- End-user definition
- Probable use
- Design
- Iterative prototyping/evaluation
- Evaluation

It was further concluded that it would be useful to finish and possibly develop the matrix on studies and methods that has been started within HUMANIST.

A further development of the matrix might include the following information, using the SafeTE method as an example:

Name and short description of model/method

SafeTE - safety assessment of IVIS

Context – used in what study?

SafeTE validation study

Context – used in what stage of the design process?

Evaluation of existing system

Evaluation of system at several stages of the design process for iteration

This kind of information could act as a good support/toolkit for both designers and evaluators in the user-centred design process.

During the second day of the Vienna workshop eight presentations were held. To some extent the methods used in the studies presented were related to the discussion from day one. All the presentations from the workshop can be found in “Report on interest and use of joint-cognitive models for human centred design”, deliverable C.6 from TFC.

5 Reference

Engström, J., & Mårdh, S. (2007). SafeTE final report. *Vägverket rapport 2007:36*

Deliverable C.7

Annex I

6th Framework Programme
Priority 2 “Information Society Technologies”
“**HUMAN** centred design for **I**nformation **S**ociety **T**echnologies”

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Intermediate reviews of knowledge on Human Centred Design applied to IVIS and ADAS

Deliverable 5 of Task Force C

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SUMMARY

This deliverable, “Reviews of knowledge on Human Centred Design (HCD) applied to IVIS and ADAS systems”, is a result of HUMANIST TF C WP C.3 “Development of ergonomic design criteria” work. The objective was to provide guidelines or code of best practices to ensure that IVIS and ADAS are designed to ensure usability and safety requirements. The deliverable is to viewed as a living document which will be revised as part of the TFC work and a revised version will be issued as Deliverable C7 "Final Reviews of knowledge on Human Centred Design applied to IVIS and ADAS systems" (due month 44) Thus, there will be room for improvements, consolidations and extension of the application of HCD to the design of ADAS and IVIS. Two important “tools” have been used in this task; the theoretical framework provided by Joint Cognitive model of Driver-Vehicle-Environment (Chapter 2) and a description of User (Human) Centred Design approach (Chapter 4). A theoretical framework can be a useful tool in many aspects (e.g. understanding observed problems, develop ideas on how to resolve problems, and for evaluating the implementation of problem solving ideas). However, so far we are still waiting for models or theories that are both comprehensive and deep and that capture the interaction between driver- vehicle and environment. The current DVE model is based on Cognitive Engineering but new development in e.g. neurobiology can possibly contribute to an even better understanding of driver behaviour. Criticism is a valuable tool to improve what we have so far thus chapter 3 constitute a critical review of the current DVE. However, no new DVE model is proposed here. There are other important instruments that can contribute to improve the design of in-vehicle driver support systems like IVIS and ADAS e.g. standards and guidelines. However, it seems like the current recommendations as in the European Statement of Principles (ESoP) do not provide sufficient guidance on the implementation of IVIS and specifically ADAS (Chapter 5). Even so, it does provide very useful ideas on the implementation of the design process. The following chapters (6 – 9) consist of descriptions and review methods that have been used or are proposed for use in the design of IVIS and ADAS. These systems cover both qualitative and quantitative methods; all of them require participation of users which is well in line with the Human Centred Design approach. Most methods are more applicable to IVIS than ADAS as they focus on the evaluation of a more explicit interaction between the user/driver and the support system. IVIS is more informative while ADAS are more directly coupled to the driving task or even intervene with the driver’s control of the vehicle. Such a close interaction does not require traditional displays while they at the same time are more time critical. It can be questioned whether the proposed objectives have been achieved or not. It seems like the current review does not provide enough knowledge and experience in order to specify definite guidelines and best practice. There remains quite a lot of work to be done before we know which method is best suited for what part of the design process. However, we can say that both quantitative and qualitative methods should be used (further work in C7). Furthermore, we need to carefully consider the limitations of the methods and how they can be used both in the different phases of the development and for different aspects of the driving task. Finally, it should be noted that we have not at all considered how to incorporate various user groups in the design process but a general recommendation is to not rely too much on young healthy male drivers. The deliverable ends with chapter 10 and 11 which provide a discussion and some conclusion concerning the work carried out here.

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• ABBREVIATIONS

Acronym	Description/Definition
AAM	Alliance of Automobile Manufacturers
AAP	Adaptive Accelerator Pedal
ACC	Adaptive Cruise Controller also called Autonomous Cruise Control
ACEA	European Automobile Manufacturers' Association
ADAS	Advanced Driver Assistance System. Systems that interact with the driver with the main purpose of supporting the **driving task** on the tracking and regulating levels.
AICC	Adaptive Intelligent Cruise Controller (Same as ACC)
COCOM	Contextual Control Model (See Hollnagel and Woods, 2005)
DVE	Driver-Vehicle-Environment
ECOM	Extended Control Model (See Hollnagel and Woods, 2005)
ESC	Electronic Stability Control (equal to ESP) a system to improve lateral control of a vehicle
ESoP	European Statement of Principles
ESP	Electronic Stability Program equal to ESC a system to improve lateral control of a vehicle
DVE	Driver-Vehicle-Environment
FGI	Focus Group Interviews
HCD	Human Centred Design
HMI	Human Machine Interface. A set of components that govern the interaction between the user and one or more vehicle systems
HMI	Human Machine Interaction
ISA	Intelligent Speed Adaptor/Adaptation
IVIS	In Vehicle Information System. Systems that interact with the driver with the main purpose of supporting tasks on the targeting and monitoring levels, or do not support driving at all.
JCS	Joint Cognitive System (See Hollnagel and Woods, 2005)
OEM	Original Equipment Manufacturer
PDA	Personal Digital Assistant
RHT	Risk Homeostasis Theory (Wilde, 1982)
STORM	Stuttgart Dual Mode Route Guidance
UCD	User Centred Design
TF C	Task Force C (part of the Humanist project)
TSOT	Total shutter open time
TTT	Total Task Time

• 1. INTRODUCTION

This deliverable aims at providing some guidelines or at least some ideas on how to apply the Human Centred Design (HCD) principles in the evaluation of ADAS (Advanced Driver Assistance Systems) and IVIS (In Vehicle Information Systems). Human Centred Design and User Centred Design (UCD) are used as synonyms here. The HCD process is iterative and should include several checkpoints with evaluation of the current design with respect to the intended user. The approach used was to collect information from TF C partners on different methods they have used to evaluate in vehicle driver support systems like ADAS and IVIS. Furthermore they were asked to tell in which phase of a User Centred Design process and how they thought the method described would fit best. Finally, they were asked to give information about what they thought was missing in the described method in order to make full use of it.

To make it easier for the contributors a more elaborated description of Human Centred Design was compiled and distributed. Furthermore, a short description of a Driver Vehicle Environment (DVE) model as developed in the context of Cognitive Engineering and applied in projects like (AIDE IST-1-507674-IP) aiming at developing methods that can be used by the industry to evaluate future ADAS and IVIS. However, the DVE model proposed by the AIDE project was discussed and criticised during a Humanist TF C workshop held in ISPRA, May 2005 (Macchi, Re, & Cacciabue; 2005) and it is obvious that there is a need to further develop the theoretical models of driving behaviour in order to make them more comprehensive and possible to operationalise. Finally, a partner was asked to provide a current status of the European Statement of Principles and to identify possible gaps with respect to ADAS and IVIS. In the following references are given in relation to each chapter.

The work was divided among partners as follows:

- Introduction – VTI
- DVE model from AIDE – VTI
- Criticism of DVE – TOI
- User Centred Design – VTI
- ESoP – current status and gaps – TRL
- Review of methods – VTI, CDV, FACTUM, OHG, CUT, BAST
- Discussion and conclusions – all (mainly VTI)

The following instructions were given to the partners who were asked to describe methods:
Please use the following five headings when describing the methods you have used for the evaluation of ADAS and IVIS in the past.

Project
Provide information about the project in which the method was developed and tested. This will give a possibility for the reader to have a reference that can be used when searching for more details.

Purpose of method
Make sure that the following is covered in this section:

- *purpose of the method*
- *user of method (manufacturer/developer, authorities, test institutes)*
- *when the method is used: as a design support during development where the test results are feed back into the design process, or after market introduction, as e.g. Euro NCAP.*

Description of method
Describe this with the joint cognitive model in mind

Also describe what functionalities of ADAS and IVIS are covered with this method:

1. *Driver/system interaction. No warnings or vehicle behaviour effects. E.g. phones and nav-systems*
2. *Driving assistance, but no intervening. Only warnings. E.g. warning of too close to lead vehicle*
3. *Intervening driving assistance. E.g. Electronic Stability Control*

Specific Human Centred Design components

Describe where in the Human Centred Design cycle the reviewed method applies. See Figure 1. Checklist for this section:

- *Evaluation? (most certainly included)*
- *Method includes tests with human subjects?*
- *Can the results of the evaluation be used as input in the user needs analysis and system requirements definition? If so, how?*

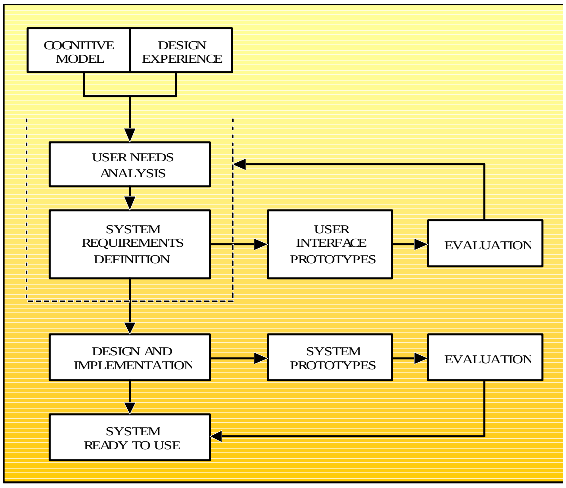

Figure 1 The human centred design cycle described in the Technical Annex of HUMAINST

Towards a Human Centred Design method

Describe how the method should be completed to become usable as a Human Centred Design method. What parts are missing? What parts are there, but incomplete?

Also give your opinion of how applicable the method is and can be (if completed) on different types of ADAS/IVIS. Is the method very system-specific? Or is it general?

a Reference

Macchi, L., Re C., Cacciabue P. C. (2005), Modelling Driver Behaviour in Automotive Environments, EUR report: EUR 21677 EN, LB-NA-21677-EN-C, ISBN 92-894-9628-2.

• 2. DRIVER VEHICLE ENVIRONMENT MODEL

The joint cognitive model described here is required for an equal use and descriptions of phenomena and concepts relevant to driving. The model is based on the outcome of the Humanist WP C.3 workshop on "Joint-cognitive models of Driver-Vehicle-Environment" in Ispra 2005, and in particular on AIDE deliverable 2.2.5 Östlund et al. (2006).

a Driving as hierarchical control

i Control

Driving could be considered as an instance of the more general notion of *driver behaviour.* Behaviour, as opposed to mere bodily movements, can be conceived of as goal-directed activity. Thus, *driving* can be thought of as a set of behaviours directed towards goals associated with vehicle operation. *Control* is a useful concept for describing the dynamics of goal-directed behaviour, in humans as well as in machines. Controlling a process means that control actions are determined by the aim to achieve a consistent goal state (often called the reference or target value), e.g. by means of countering effects of external disturbances. Control is thus closely related to orderliness or predictability, i.e. a controlled system is ordered, stable and predictable while a system that is out-of-control is disordered, unpredictable and unstable.

Control comes in different varieties: In *feedback control*, the controller performs corrective actions based on the deviation between a desired outcome (the goal) and the actual state. A prototypical example of a feedback control is the thermostat. Another type of control is *feed forward*, or anticipatory control. In this case, control actions are based on predictions of future states, and not purely reactive as in feedback control. Driving behaviour involves both feedback, feed forward and mixed control loops. This mixture of control was nicely described by McRuer et al. (1977) for the driver's steering control.

Control theory has been widely applied to the modelling of operator vehicle handling, in automotive and other domains (e.g. Weir and McRuer, 1968; Weir and Chao, 2005; Donges, 1978). In these types of models, vehicle control is mainly modelled in terms of feedback control mechanisms where control inputs (steering wheel/pedal movement) are translated, via the vehicle dynamics, into vehicle position/heading values that are fed back to the human controller. An example of such a model is illustrated in *Figure 2*.

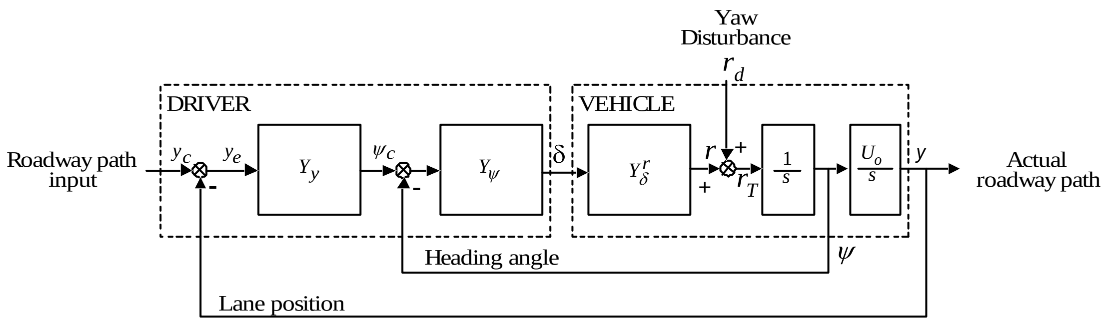

Figure 2 Example of control-theoretic steering model (from Weir and Chao, 2005)

A common criticism of these classical control models is that they are based on the assumption of the controller as an *optimiser*, i.e. with the goal of always minimising the difference between the target value and the actual state. However, humans rather tend to act as *satisfiers*, i.e. they do not put more effort into a task than needed and we tolerate some deviation from a perfect control i.e. no deviation from the target value. In the case of driving, there is considerable evidence that drivers adopt time-based *safety margins* as the criteria for vehicle longitudinal and lateral control (Gibson and Crooks;

1938, Lee, 1976; Godthelp, Milgram and Blaauw, 1984; van Winsum, 1996; van der Hulst, 1999; Boer, 2000; Nilsson, 2001, van der Horst, 2005).

A general account for human control of a process or plant, based on Neisser's (1976) cognitive cycle concept, is offered by the Contextual Control Model (COCOM) as described in e.g. Hollnagel and Woods (2005). An important starting point for COCOM is that the controller and controlled system is viewed as an integrated Joint Cognitive System (JCS). A key concept in the model is the *construct*, which refers to what the controller knows or assumes about the situation in which the action takes place. This understanding is the basis for controller's selection of actions and interpretation of the system's state. The selected actions affect the process/application under control. Actions and external disturbances modify the system' state which is perceived by the controller as a construct of the system state and determine future action selection. Thus, an important property of this model is thus that it captures both the feedback and feed forward aspects of control, i.e. action selection is a function of both direct feedback and the prediction of future events.

Another key property of COCOM is that it offers an explicit account of time. As illustrated in Figure 3, the model contains three basic time parameters: (1) Time to perceive, (2) time to decide and (3) time to act. As in any control system, the relations between these different time parameters strongly determine the performance of the JCS. For instance, long delays between action and feedback, such as in the control of a large ship, make feedback control difficult and thus put greater requirements on feed forward control mechanisms. Moreover, the time needed to perform one cycle must be less than the total time available. If not, the control will deteriorate and become sluggish. However, the available time may be increased by slowing down the pace of the task, e.g., in the case of driving, by reducing speed. The paradox is slow down to gain time.

T_{Act}

$T_{Perceive}$

T_{Decide}

Figure 3 ***The Contextual Control Model (COCOM) (Hollnagel and Woods, 2005)***

i Hierarchical control

While COCOM only describes a single control process (i.e. pursuit of a single goal), the driving task can be viewed as the pursuit of several sub-goals with different time frames. A long-term goal could be to reach a destination in time. A medium-term scale goal would be to overtake a lead vehicle, while short-term goals include staying in lane and avoiding obstacles. A goal may also subsume goals on shorter time frames. For example, in order to reach a destination in time, it may be necessary to overtake a number of vehicles. This, in turn, requires safe vehicle handling in order to avoid collisions. Thus, the driving task can be described as a set of simultaneous, interrelated and layered control processes. In addition, drivers generally pursue many goals that are totally unrelated to driving e.g. talking to a passenger, using a cell phone.

This hierarchical organisation is reflected in many driver behaviour models, (e.g. Allen, Lunefeld & Alexander (1971)) and Michon's influential description of the driving task in terms of strategic, tactical and operational levels (Michon, 1985). While, Michon's model is useful as general descriptive frameworks, it does not account for driving control as such. More specifically, it does not account for the dynamical aspects of driving, nor the relations *between* control processes on different layers.

A general framework for describing behavioural dynamics in terms of hierarchical control has been offered by Perceptual Control Theory (e.g. Powers, 1998; Marken, 1986). Hierarchical control models of behaviour have also recently been very influential in the field of mobile robotics (e.g. Brooks, 1986). In the automotive field, a hierarchical control model of driving has been proposed by Hollnagel in terms of the ECOM (Extended Control Model) (e.g. Hollnagel, Nåbo and Lau, 2003; Hollnagel and Woods, 2005; Engström and Hollnagel, 2005). The basic structure of ECOM is illustrated in Figure 4.

Figure 4 ***The Extended Control Model (ECOM)***

A basic assumption behind the ECOM model is that goals corresponding to different layers can be pursued simultaneously, and that these goals and their associated control processes interact in a non-trivial way. In the current version, four control layers are postulated: tracking, regulating, monitoring and targeting. A key property of the model is that, during normal (controlled) task performance, the goals/targets for the control process on a given layer are determined by the control process one layer up. In the driving domain, the *tracking* control refers to the momentary, automated, corrections to disturbances, e.g. wind gusts. *Regulating* refers to more conscious processes of keeping desired safety margins to other traffic elements. This determines the target values for the tracking loop. *Monitoring* refers to the control of the state of the joint vehicle-driver system relative to the driving environment. It involves monitoring the location and condition of the vehicle, as well as different properties of the traffic environment, e.g. speed limits. This generates the situation assessment that determines the objectives for the regulating layer. Finally, the *targeting* control level sets the general goals of the driving task, which determines the objectives for the monitoring layer. As illustrated in Figure 3, tracking control is typically feedback while monitoring and targeting are generally feed-forward. The regulating layer may involve a mix of feedback and feed forward control. The ECOM model provides a neat account for how goals at different layers interact and how higher goals propagate all the way down to moment-to-moment vehicle handling. Control tasks on different layers may also interfere. For example, looking for directions (monitoring) may disrupt visual feedback which may affect regulating and tracking control. Driving means that control has to be carried out on different layers simultaneously and timing (synchronisation of goals and feedback) becomes critical.

Importantly for present purposes, driving performance can be defined with respect to any of these layers. For example, the ability to find a destination would be related to performance on the monitoring layer, the ability to keep safe distance related to the regulating layer and the ability to stay in lane related to the tracking layer and so on.

In addition to driving-related activities, drivers may also engage in other types of behaviour directed towards non-driving-related goals, e.g. tuning the radio or talking to passengers.

a Functional mapping of ADAS/IVIS to ECOM

A general distinction is often made between ADAS (Advanced Driver Assistance Systems) and IVIS (In-vehicle Information Systems). In general, there seems to be a consensus that ADAS refer to systems mainly intended to support the (primary) driving task, while IVIS are systems mainly supporting other (secondary) tasks. Many projects define their scopes in terms of these categories (e.g. in HASTE, the developed evaluation methodology is only applicable to IVIS). However, this distinction is somewhat problematic, since many functions that support the driving task on higher levels (e.g. route guidance, traffic information and speed alert) may interfere with driving at lower layers in the same way as "typical" IVIS such as the radio, mobile phones etc. Thus, these systems/functions are often considered as being in a "gray zone" between ADAS and IVIS.

This issue can be resolved based on the present framework, where functions can be described in terms of the driving sub-task (i.e. which goal) that they support (where some systems may not support driving goals at all). In this context, it is more useful to talk about "functions" than "systems", since a system may contain many functions of very different types. A tentative mapping of some example IVIS and ADAS functions onto the ECOM layers is illustrated in Figure 4. This taxonomy is intended as a complement, rather than as an alternative, to the more traditional taxonomy of IVIS and ADAS (Floudas et al., 2004).

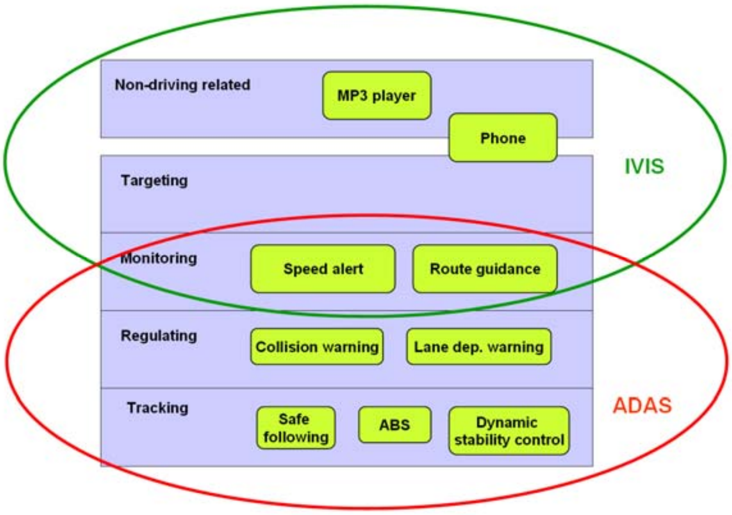

Figure 5 Proposed mapping of the ADAS/IVIS categories and some example functions onto the ECOM layers.

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3. COMMENTS AND REMARKS TO THE "DRIVER VEHICLE ENVIRONMENT MODEL"

Truls Vaa (TØI)

a Driving as hierarchical control

The control model/theory is an interesting example of application of physics/cybernetics on (driver) behaviour and an example of control-theoretical steering model from Weir and Chao in (2005) can be seen in *Figure 2*. At the core of the model, is the aim of achieving and/or maintaining a consistent goal state, often called the reference or target value. The control model dynamics then resembles other driver behaviour models dynamics as we know them from traffic safety research: Näätänen and Summala's "zero-risk-model" with no accidents or "zero-risk" as the target value (Näätänen and Summala, 1974) and Wilde's "Theory of Risk Homeostasis" (RHT), with target ***risk***, typically a number > 0, as the target value (Wilde, 1982). The relationship between Wilde's RHT and Weir and Chao's steering model is striking, as also Wilde's RHT explicitly uses the thermostat (Wilde's concept is "the comparator"), and a feedback loop as the core of his model. More recent models use other concepts than target value, as with "functional balance" in Damasio's model (1994), and "target feeling" or "best feeling" in Vaa's model (2005). Given the feedback loops, and the concept of a target as a governing principle, all these models can be said to belong to the same group of models. That said, one might assert that the control-theoretical model is more "machine-like" than the others as it does not involve the human organism as a factor in itself in the model. The scope of the control model, here addressing steering only, could be said to be "the vehicle", or the steering angle of the vehicle, of which the human operator is only an implicit part of the system, i.e. not explicit.

It could, hence, be claimed, that the control-theoretical model would have its limitations: What exactly would be the range of its applications, what kind of driver operations could be said to be of a kind where operations should only appear within defined limits, i.e. within a certain interval of target values? Having said that, this range of applications could indeed be wider if one considers speed and time headways. ISA (Intelligent Speed Adaptation), which denies driving speeds above speed limits (the target value) could be extended to include also a lower limit, i.e. the driver should not be allowed to drive under certain speeds in specific road environments. AICC (Adaptive Intelligent Cruise Controller) and the regulation of time headways could be another example where a control-theoretical model could come into operation in a profitable way. It presupposes, however, that these systems are fail-safe, i.e. the identification of situations where systems are applicable is clear-cut and explicitly well-defined. Electronic Stability Control (ESC) or Electronic Stability Program (ESP) might be an example where control theory has been put into practice, as ESP operates by comparing the yaw rate and lateral acceleration. The difference between the two parameters is compared, it should in principle be +/- zero, but if increasing above a certain target value, ESP is activated, and the difference is again brought back towards zero. This is maybe what is called "yaw disturbance" in figure 2, and it seems like it is really a control-theoretical model which is the basis of the development of the ESP. Thus, it is an excellent example of how a theoretical model would predict a beneficial outcome on traffic safety as several evaluation studies have documented a considerable effect of ESP on the number of accidents (Lie et al, 2004; Farber 2004; Dang 2004).

a The COCOM and ECOM models

The COCOM and ECOM models are probably too generic and not specific enough. Thus, there is a need to further develop the ideas in order to further exploit the concepts. Some criticism and suggestions for improvement are given further on. Proceeding to the sections describing the Contextual Control Model (COCOM), one is faced with several questions and problem statements:

- The starting point of the COCOM discussion, human control of a process or plant, is particularly unfortunate, because "control of a process or plant" predominantly produce associations to ***static*** systems, as power plants, control room operations and the like. And static systems is regarded as highly irrelevant for a study of car driving, where the dynamics of the car-driver-environment entity, the continuous shifting time-windows, the involvement of the body and bodily reactions, is a very special kind of human behaviour, which hardly resembles any other kind of human conduct, especially not in static systems.

- The un-reflected adoption of the concept of cognition ("***cognitive*** cycle concept" (Neisser, 1976) "Joint ***Cognitive*** System", Hollnagel and Woods; 2005) introduces an unlucky bias right from the outset as "cognitive" and "cognition" is traditionally used to refer to higher mental operations as thinking, conceiving and reasoning, i.e. to ***conscious*** processes. Then one escapes the unconscious parts of decision-making and on the whole of the interaction between conscious and unconscious processes. As a consequence, the subsequent discussions and the comprehension of the subject matter has to be limited and of limited value.
- *"Construct"* as a key concept in the COCOM model: Proposing "*construct*", defined as *"…what the controller knows or assumes about the situation in which the action takes place",* as a key concept, shows that the model is biased towards conscious processes ("..the controller ***knows..")*** and illustrates the superficial nature of the COCOM model. There is no discussion of unconscious processes, automated information processing and decision-making, no discussion of learning, especially no reference to implicit learning, or "unconscious learning" (i.e. learning that takes place largely independent of awareness of both the process of acquisition and the content of the knowledge so acquired). Further, one should ask for the empirical basis of the concept of a "construct": Do drivers really utilize conscious decision-making through establishing a construct concept?
- The COCOM model is said to *"…capture both the feedback and the feed forward aspects of control…"*, which is regarded as an important property of the model. This statement again shows the superficial nature of the model as it does not consider the intricate mechanisms of information processing and decision-making. One important contributor here, probably the most important contribution, is made by Reason (1990) in his elaboration of a complete model of information processing. Further, the separation between feedback and feed forward aspects is artificial. Considering the process of driving, the human organism continuously receives feedback upon his/her actions, there is a continuous recognition of road environment parameters, which invoke earlier experiences with similar environments, known as *schemes* stored in long-term memory (also known as the knowledge base), information processing and decision-making are done for the most part in an automated manner, i.e. unconsciously. This is regarded as the most economic way of driving, anything that can be done in an automated manner is actually automated (consider walking, cycling etc), there is no (conscious) decision of automated actions this is something the organism "decides" without considering it consciously. An involvement of conscious processes (thinking, reasoning, weighing pro and cons, etc), is costly and demanding in terms of mental processes and the organism then "rely" on the schemes, i.e. previous experiences with analogues situations. The COCOM model totally escapes this understanding of the driver (the alternative sketch provided here is very crude, the processes are indeed much more intricate than described above, but it is nevertheless a sketch of processes that the COCOM model seem not consider at all).
- Another key property of COCOM is said to be *"…the offering of explicit account of time by three basic time parameters: (1) Time to perceive, (2) time to decide and (3) time to act".* It may again apply to static systems, power plants and control room operations in general, but it is likewise again questioned whether this categorisation apply to a dynamic process like driving where perception, information processing (why is there no separate category for this in the COCOM model?), and decision-making should be regarded as continuous, stimuli is received and processed continuously by the human organism, but there is no conscious recognition of these processes with respect to time consumption (there is no need to) (Damasio, 1994). What is left is only the 3rd category *"time to act*" (although the driver considers action all the time by, predominantly unconscious, appraisals of maintaining or changing actions of steering, lateral positions, time headways, driving speeds, etc). The entity of time to act, would probably be more in terms of *distraction times*, i.e. an experienced driver may allow him-/herself times of distraction ("how long can I be distracted from the primary task of driving"), when talking to/looking at passengers, operating a radio/CD-player, reading a map or street name, watching landscapes and the like. But also these distraction times are governed by schemes and they depend on the driving speed, road environment (built-up area, rural, etc) and would typically be shorter in a built-up area where intentional checks are needed at a much shorter pace than on a rural road. Again, the COCOM model operates at a very superficial level, by leaving the above issues un-reflected without consideration and without discussion.

- The ship analogy: I also disagree on the reference to the ship analogy. Disregarding that a "ship" is not well-defined as it varies considerably in size and sailing speeds, it is still a dynamic system and ship handling and operations would in principle also make schemes on basis of concrete situations and experiences, which subsequently would govern information processing and decision-making. Ship operations may allow for a larger amount of conscious appraisals given the slower pace, and it is of course different from driving regarding on-board systems as radar, GPS, maps, etc and the utilization of a variety of land- and sea-markings. But the dynamics is still there, the ship is moving and the body moves with it as in the case of car driving.
- It is stated that *"The paradox is slow down to gain time"* (page 10). This is not a real paradox, it is kind of obvious that one will gain time by slowing down and it is typically what drivers do when road environments are getting increasingly complex (and vice versa). It is called compensation and may operate in two dimensions: Speed and attention. By applying Damasio and proposing that it is the functional balance of the organism which is taken into account in a given situation, it is suggested that the driver, i.e. the human organism is governed by a target ***feeling***: If the driver is facing a complex situation where interaction with several road users may take place, the body "tells" the driver to slow down, with a "warning", may be called an anticipatory act or a feed forward, but it is basically an emotional warning: "Something unpleasant will arise if speed is not reduced".

In the section "Hierarchical control", there is initially a section on activities that have to be dealt with in the course of driving, i.e. there is a difference between "short-term", "medium" and "long-time goals". This seems plausible, it is basically a distinction between temporal/stable motives at work and a suggestion of a hierarchy of motives. There is also a reference to Michon and a categorisation of driving tasks into strategic, tactical and operational levels. It is stated that Michon's model is useful as a general descriptive framework, and I agree to that. I see it, however, differently, i.e. that Michon's categories are somewhat arbitrary and that the distinction between groups or tasks is masking what is really going on. My understanding of this hierarchy (or what one chooses to call it) is different. What really varies is the relative amount of consciousness and operations which are handled unconsciously, i.e. in an automated manner. Tasks on a strategic level would be fully conscious; a task on a tactical level is mixed, while a task on an operational level would be performed without involving consciousness at all. What is characteristic for the driving process and the human organism is a fluctuation between conscious and unconscious entities which takes place all the time in the course of driving, a complete separation between thinking (consciousness) and the vehicle handling may take place, typically experienced when a driver "wakes up" and cannot recall anything from the last kilometre driven. Again, experienced drivers will let, as much as possible, the vehicle handling to be done in an automated mode, and only involve conscious considerations when necessary. This in-and-out of conscious appraisals and automated handling is not decided consciously, but "decided" by the organism itself, then dependent on the continuously shifting time-windows experienced by the driver. This is an alternative description and a somewhat different explanation of what is going on.

However, proceeding to the ECOM-model and the four-layered model of targeting, monitoring, regulating and tracking, I cannot really see it to be significantly different from Michon's model, as it still functions on a level of description, although with somewhat differing categories. But there is still no theory behind it, there is no reference to learning processes or neurology, no model of information-processing and decision-making and there is a big difference in the levels of sophistication between the ECOM-model and Reason's model regarding the intricate mechanisms of information-processing. My preference is with Reason's model (Reason, 1990). Further, the model lacks a theoretically based justification of why exactly these categories should build a hierarchy, the same applies to the rank order between them. I also disagree with the proposed ECOM-hierarchy by again referring to Damasio and his conception of monitoring (of risk) as the organising dimension by axiomatically asserting that survival is the most basic and fundamental motives of all motives (Damasio, 1994, Vaa, 2005). Hence, the ECOM-model is just providing a new set of concepts, maybe applicable for description purposes, but the model does not seem to provide any basic understanding and seemingly neither any valid predictions.

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• 4. USER CENTRED DESIGN

Selina Mård Berggren (VTI)

User needs, constraints, and interests are the primary focus in a user centred design process. The designer's aim should be to make the product/system easy to use and understand. A perfectly usable product/system needs no instructions or labels. The use of the system should be intuitive, effortless, and evident even at the first try. The aim of the design should be to simplify the complexity of the product/system.

In a traffic environment the primary task is to drive a vehicle and the secondary task could be to handle other systems in the vehicle, such as IVIS or ADAS. Applying user centred design in development and evaluation of an IVIS or an ADAS takes on slightly different demands than design of other artefacts. The product/system must be non-intrusive and extremely easy to handle and understand since a system that is too complex or demanding will pose a threat to traffic safety. Thus, making usable systems design an even more important issue. A usable design in this case is a matter of life and death.

To clarify the user centred design process, a description of the concept usability and its real world usage through the design process and evaluation will be explained. This text will also highlight the main features of good design and product/system development.

a Usability

Usability is an important aspect in the process of designing a product/system that is surely usable, easy to learn and remember, and easy and pleasant to use. This can be achieved by performing user studies and by considering usability issues throughout the whole development lifespan of a product/system, from idea to product/system. This is the user centred design process. A user centred design process urges the designer not to trust their instincts but to study people, take their needs, interests and prerequisites into account all through the design process. The concept of usability is focusing on the future user of the product.

Usability is strictly related to the ways a product/system is used in a specific culture. Everyone sees and interprets the product/system through his/her own culture. "Cultural issues" is a broad concept that includes not only ethnical culture but also gender, age, social status, education, disabilities and such. All these factors colours the way in which users interact with artefacts in their surrounding, hence cultural issues are important to take into account in the design process.

a The user centred design process

There are a number of different methods to accomplish a usable product/system. In the following section, a very simple but functional model for a user centred design process is presented (see *Figure 6*).

Figure 6 User centred design process (model by Selina Mård Berggren)

a Idea generation

An idea for a new product/system is born. The idea generator needs to consider the likeliness of the idea to work. The idea needs to be tested, considered and developed.
Suggested methods: Expert discussions, brainstorming, workshops, questionnaires, focus groups and/or interviews.

a Usability planning

A thorough usability planning is essential and an important foundation for proper usability work. An explicit and structured plan for the usability work involved in the design process should be developed. It should comprise choosing adequate methods for the different stages of the design process and plan coordination of activities involved. A final consideration is to define the usability goals according to the probable context of use. The goals can then be used as end-point for the design.

i End-user definition

The end-user needs to be specified in the beginning of the design process; Who is the design for? Usability is always aimed at the end-user, even though other interested parties might demand to influence the product/system. Good knowledge of end-user is a "must-have" for successful design. Unless the knowledge is already present, it needs to be collected in this early stage. Further, context of use as well as cultural issues needs to be gathered and considered. What prerequisites does the intended user have? This demands good knowledge of the target end-user group.

Suggested methods: Focus groups, interviews, story boards, development of personas, and/or gathering of statistics.

i Probable use

Probable use refers to the probability of the product/system to be desired by the potential end-user. This also has a dimension of profit – is the product/system desirable enough to have a market? Other aspects to regard at this stage are; Who is the customer? Who is the beneficiary? Who is paying for the product/system development? Who is paying for the end product/system?

Suggested methods: Market surveys, focus groups, interviews (attitude assessment), collection of statistics, and/or questionnaires.

a Design

In the design phase the first prototypes begins to appear. Both lofi (low fidelity) and/or hifi (high fidelity) prototypes can be developed to visualize the design ideas. A lofi prototype could for instance be a static model of the menu system of a navigation system. No functionality is present, but the different layers can be visualized. An example of a hifi prototype is a mock-up with proper functionality; it could be an early model of the product/system intended.

Suggested method: Prototyping

a Evaluation

Evaluation and design of the product/system are two components of the product/system development that are not easily separated. It is necessary to alter between the two throughout the process, hence creating an iterative work process. The design and evaluation phases are iterative in the sense that a design developed is evaluated and the feedback and documentation from the evaluation is used in further product/system development and design.
Evaluation can be performed in all stages of product/system development and can be considered threefold:

- Firstly, the purpose of evaluation in the design process is to ensure that the product/system development is on track.

  Suggested methods: User-based evaluations such as walkthroughs, Wizard of Oz, think-aloud protocol, observations and/or focus groups.

- Secondly, another aspect of evaluation is verification of product/system usability at the very end of the development process.

  Suggested methods: Walkthroughs, Wizard of Oz, think-aloud protocol, observations, focus groups, in-home trials, heuristics, expert evaluations, checklists.

- Thirdly, evaluation can also be performed after the completion of the product/system. This is often done by others than the developer and designer. An example of this is the rating system of EuroNCAP where new cars are assessed according to a rating system mostly concerning traffic safety.

Suggested methods: Walkthroughs, Wizard of Oz, think-aloud protocol, observations, focus groups, in-home trials, heuristics, expert evaluations, checklists, simulator studies.

The evaluations should be planned, supervised, and interpreted by a trained usability expert. Personnel performing the usability assessments should be adequately trained.
From a usability process point of view it is highly desirable that a project group developing a usable product/system comprise people with different kinds of expertise. That way you ensure a design process that take different aspects into account from the beginning. Hence, the group working with developing the product/system should consist not only of the developer but of people from all the product life stages such as the idea generator, usability expert, software developer, interaction designer, industrial designer, as well as people from marketing.
So far, the text has dealt with general considerations and suggested methods for the user centred design process. To clarify the specific considerations for good design, a basic checklist of questions to ask follows (Norman, 1998). The checklist can be used both in the design process as a way of reflecting over the design achieved so far, as well as in the evaluation of a complete design.

How easily can one:

- Determine the function of the device?
- Tell what actions are possible?
- Tell what state the system is in?
- Tell if a system is in desired state?
- Perform the action?
- Determine mapping from system state to interpretation?

a Main principles of good product/system design

The first and seemingly most important question to be asked when evaluating a product/system is:

Does the system allow the user to perform the intended action, i.e. provide actions that correspond to the intentions of the user?

The main principles of good product/system design stipulate the following aspects:

i Visibility

By looking, the user should be able to determine the state of the device and understand the alternatives for action. Also only the relevant parts should be visible at any given moment.

i A good conceptual model

The designer should provide a good conceptual model for the user, with consistency in the presentation of operations and results and a coherent, consistent system image.

i Good mappings

It should be possible to determine the relationships between action and results, the relation between the controls and their effects, and the relation between the system state and what is visible to the user.

i Feedback

The user should receive full and continuous feedback about the results of action. The feedback should be immediate and obvious.
(Norman, 1998)

a Appearance counts

Although this document pleads for usability as the primary consideration in the design of a product/system, designing for appearance is important. Users tend to be more forgiving towards an attractive design. A beautiful product/system is approached with more patience than an ugly one. Hence appearance is part of a truly usable product/system.

a Concluding remarks

- In a user centred approach to design, the developer ensures that products/systems developed are both usable and desired by the end-user.
- The user centred design process takes usability into account through an iterative design process where considerations of the end-users are maintained throughout the whole design process.
- The end-user is involved in formalized evaluation of the product/system during all stages of the development.

The above considerations ensure that the development and design of usable products/systems serves the purpose of the intended user.

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5. European Statement of Principles – Review and Identification of Gaps, specifically in view of HMI design

Alan Stevens & Sally J Cotter (TRL)

a Introduction

The European approach is to support the development of HMI standards and specific functional standards at European and International level and to develop relatively high-level guidelines (called principles) concerning overall HMI design issues. Detailed HMI guidelines or regulations are likely to be related to specific technologies. The expectation is that principles that focus more on the users will be technologically neutral or, at least, more resilient to developments in technology. This was the basis for development of the European Statement of Principles (ESoP).

a Development

In December 1999, the EC adopted a Recommendation [1] incorporating the "European Statement of Principles" (ESoP). In addition, the EC published an expansion of the principles by its expert group in 2001 [2]. The documents contain three overall design principles on human machine interaction and 32 principles covering the topics of system installation, information presentation, interaction with displays and controls, system behaviour and information about the system. The purpose of the EC recommendation was to widely disseminate the principles, through the Member States (MS), to the main stakeholders. A voluntary agreement from European car manufacturers to fully respect the ESoP was issued in 2001 by ACEA (the European Automobile Manufacturers' Association).

Under eSafety a Working Group on HMI was established in 2004 to tackle the important issue of driver interaction with on-board devices, such that HMI does not become a barrier to deployment. One of the key areas of focus for the group was the European Statement of Principles (ESoP) on HMI.

The application of the 1999 ESoP by car manufacturers and suppliers of original equipment was judged positive, but it was concluded that the impact of the ESoP could be improved for other stakeholders, e.g. "nomadic" device manufacturers (e.g. mobile telephones and PDA) and service providers. Information from the EC Member States concerning impact of the ESoP was also studied. Based on these responses and further reflection, the Working Group made a number of recommendations concerning ESoP development, the full text of which can be found in the Working Group report [3]:

- Explicitly address information presentation by service providers (e.g. running text on displays).
- Explicitly address manufacturers of specific systems (e.g. medical vehicle systems, express delivery systems)
- Enhance the ESoP with additional principles that apply to Fleet Managers and Employers who have responsibilities in design, installation and use of systems by their employees
- Clarify and adequately incorporate the distribution of responsibilities
- **Enhance the ESoP by precise criteria, where possible, on the combination of several systems during retrofit and for context specific applications**

The WG-HMI also compared European, Japanese and US approaches to HMI guidelines. In the USA within an initiative by the Alliance of Automobile Manufacturers (AAM), there are some small and some more substantial differences emerging.

Introducing quantitative pass/fail criteria, as both the US and Japanese guidelines do, was regarded by the WG as problematic: criteria that are too simplistic may be spurious i.e. they may exclude good HMI solutions and may not exclude bad HMI solutions. Simplistic criteria also tend to exclude certain tasks in general and this eliminates the challenge for researchers and industry to strive for a HMI solution which permits the performance of these tasks while the vehicle is in motion. Simplistic criteria for HMI may also imply that it is safe to undertake tasks while driving whereas, no matter how

restrictive, there will always be traffic situations in which the operation of these tasks may cause critical situations.
On the other hand the AAM guidelines available at the time contained some helpful additions and clarifications that influenced subsequent development of the ESoP. For example, the revised ESoP (discussed below) benefits from a clear allocation of relevant standards, rules and directives to the individual principles and it is helpful to link available, scientifically well-founded and accepted assessment methods to specific principles.

a ESoP 2006

In responding to the Working Group report, the Commission made some funding available through existing HMI-related projects HUMANIST [4] and AIDE [5] and invited a small group of HMI specialists to implement the WG-HMI recommendations concerning a revised ESoP and to hold Europe-wide workshops to solicit feedback. The following sections describe what is expected to be the published revised ESoP, although at the time of writing the Commission communication has not been released. The revised ESoP will be available on the eSafety website [6].

a Scope

The principles apply to in-vehicle information and communication systems intended for use by the driver while the vehicle is in motion, for example, navigation systems, telephones and traffic information. They are not intended to apply to systems providing vehicle stabilization (such as ABS and ESP) or to system functionality providing information, warnings or support that requires immediate driver action (e.g. Collision Mitigation Systems, Nightvision) sometimes referred to as Advanced Driver Assistance Systems (ADAS). ADAS are fundamentally different and require additional considerations in terms of Human Machine Interaction. However, some of the principles may provide assistance in designing ADAS.

The document concerns system design and construction and includes overall design, installation, information presentation, interaction with displays and controls, system behaviour and information about the system. It is supplemented by a document on system use which includes recommendations on context/definition, driver training, use by drivers, and assessment of use.

The principles apply to all components and aspects of a system that the manufacturer intends that the driver will interact with while driving and also to certain other components and aspects that should not be used while driving. So, "the system" refers to the functions and parts, such as displays and controls, which constitute the interface and interaction between the system and the driver. The scope excludes head-up displays and aspects unrelated to HMI such as electrical characteristics, material properties, system performance and legal aspects. Some principles make a distinction between system used “while driving” (also called “while the vehicle is in motion”) and other use. Where no distinction is made, the principles refer only to system use by the driver while driving.
The principles apply specifically to vehicles of class M and N [7] (including passenger cars, trucks and buses). The principles apply to both portable and permanently installed systems. They apply to OEM systems and to after market and nomadic devices. The principles apply to HMI functionality independent of the degree of integration between systems.

The principles are not a substitute for regulations and standards and these should always be taken note of and used.

a Stakeholders involved in system design and construction

As described in the scope, the principles are intended to apply to systems and functionalities in OEM, after-market, and nomadic (portable) systems. In general, a number of organisations are involved designing, producing and providing elements of such systems and devices, including, for example:

- Vehicle manufacturer offering information and communication functionality
- After-market system producers
- Providers of nomadic device functionality intended to be used by a driver while driving

- Manufacturer of parts enabling the use of nomadic devices by the driver while driving (e.g. cradle, interface connectors)
- Providers, Broadcasters of information meant to be used by the driver while driving, e.g. RDS information, radio programme information as running text

Where systems are provided by a vehicle manufacturer (OEM) it is clear that the manufacturer is responsible for the overall design. In other cases, the “Product-Responsible Organisation” will include the organisation introducing a product or functionality into the market, part or all of which may have been designed and produced by different parties. Consequently the responsibility may often be shared between different organizations. Where the term “manufacturer” is used in the following text, this may include several product-responsible organisations.

These goals and principles are written for those who design and manufacture information and communication systems or provide functionality intended to be used by the driver while driving and presume that those applying them have technical knowledge of the products as well as access to resources necessary to apply the principles in designing these systems.

a ESoP Contents

Following a number of overall design goals, the main part of the ESoP concerns system design and construction and includes:

Installation principles (6)

Information presentation principles (5)

Principles on interaction with displays and controls (9)

System behaviour principles (5)

Principles on information about the system (7)

The principles are short statements summarising specific and distinct HMI issues. Each principle is followed by an elaboration with the following sections:

Explanation: includes some rationale and further explanation for the principle.

Examples: “Good” and “Bad” examples provide additional explanation concerning implementation of the principle.

Application: describes which specific systems or HMI functionality are being addressed by the principle as a necessary first step in determining whether a particular system’s HMI is in accordance with the principle.

Verification: provides some information to address the question of whether a system is in accordance with a principle. Where possible, a suitable method is outlined and interpretation of the resulting metric is given:

- Where the result can be expressed as “Yes/No” this indicates the availability of a clear identification of compliance with a principle.
- In other cases the approach/methods identified do not lead to simple pass/fail criteria but offer the opportunity of increased optimisation of the HMI
- If regulations are addressed the Base Directive is mentioned. The Product-responsible organisation has to comply with the current version of this directive.

References: provide additional information which may be of interest in the context of the respective principle.

Since international standards are subject to revision, the version referred to is mentioned.

Standards under revision and draft ISO standards are sometimes given in order to provide additional information for system designers.

As noted above, where possible a practical means of verifying that the principle has been followed is provided. The ESoP Development Group did not believe that the current state of scientific development was sufficient to robustly link compliance criteria with safety for all the principles.

a Role of the Driver

Where the manufacturer's intention has been clearly stated (such that the driver can reasonably be expected to be aware of it) and the driver subsequently uses the system in a way which is not intended by the manufacturer, this can be considered as misuse.

In addition to making individual system design as good as possible, the driver can be supported in the safe operation of in-vehicle systems while driving by making other aspects of the context of use as benign as possible. These non-system design aspects of the context of use can be called the "Human Machine Environment".

In the same way that the ESoP design principles were formulated to inform and influence those organisations responsible for (or contributing to) system design and construction, additional principles concerning use were formulated to inform and influence those organisations that are responsible for (or contribute to) the human-machine environment of system use. This environment includes:

- The combined use of systems to complete a task
- The knowledge and skill of the driver (in terms of the systems and tasks)
- The driving task/situation
- The social environment (including time pressure)

For a professional driver, this environment also includes:

- Tasks that are required as part of the job (in addition to the driving task)
- Company instructions and practices

So, the ESoP design principles are supplemented in the EC Communication by a document on system use which includes recommendations on context/definition, driver training, use by drivers, and assessment of use.

a Limitations and Gaps within ESoP

One weakness with the ESoP is also a strength: that is its relatively "high level" approach. This is a strength because it is relatively technology insensitive - user-centred principles are likely to remain valid across technology developments. However, it is also a weakness because:

- Principles can have exceptions
- Technology can influence principles
- Application of general principles rely on professional judgement
- There can be few specific measurable criteria

To illustrate the difficulty consider the example of attempting to write a guideline for the order of presentation of congestion information. Immediately, there are multiple possibilities, e.g.:

1. present the most important information first
2. present the information concerning the closest congestion problem first

So, in terms of a guideline, it could be agreed that "information should be presented in a logical order". However, this may be too high level to be of real use (to whom should the presentation order be logical; does it depend on the situation; how could it be implemented; how could it be tested? Etc.). Such was the challenge facing the ESoP development group throughout its discussions.

The ESoP can be criticised as being slightly un-even in its depth of treatment between principles. In part, this reflects the degree of scientific knowledge in each area but also the scope of the principle and their relationship to each other. There is no ideal and universally agreed way to divide up the field of human-machine interaction and there are, inevitably, relationships between the principles. During the ESoP revision, there was a lot of discussion on combinations and ordering of the principles. It is likely that any other group with similar background and expertise would come up with broadly similar principles but expressed in a different way.

In terms of scope, there are some declared and implied limitations:

- The principles apply specifically and only to vehicles of class M and N including passenger cars, trucks and buses but not motorcycles or other vehicles.
- The principles apply to information and communication systems and not specifically to driver assistance systems. There are issues of definition concerning whether specific functions belong to information or assistance, so the ESoP may well be applicable to some aspects of driver assistance systems.
- Head –up displays and Night vision systems are not included due to lack of scientific knowledge
- Voice controlled devices are similarly excluded

Integration of functions and systems appears very likely in the future and this may necessitate some of the principles being revised. It is unclear the extent to which all the principles apply to integrated systems.

The ESoP includes few quantitative measurement and assessment criteria. This is an obvious limitation, but it is unclear the extent to which it could be mitigated without seriously impeding innovative design. The ESoP Development Group did not believe that the current state of scientific development was sufficient to robustly link compliance criteria with safety for all the principles. In addition, the group stated their opinion that whilst systems designed in accordance with the principles are generally expected to be safer than those that do not take account of them, it *may* be possible to meet the overall design goals even if one or more principles are violated.

Overall, therefore, the ESoP can be considered as providing useful design advice but not sufficient, in itself, for undertaking a safety impact assessment of any specific function or system.

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6. REVIEW OF OBSERVATION, FOCUS GROUPS, CHECKLISTS AND EXPERT EVALUATIONS, AND INTERVIEW METHODS

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This chapter includes an overview and a review of the following five research methods which have been used extensively in the work by FACTUM and OHG:

1. Observation – "Wiener Fahrprobe"
2. Focus Groups Interviews
3. Traffic safety checklist
4. Expert evaluation – Workshop
5. Interview – In-depth Interviews

a Purpose of methods

i Observation „Wiener Fahrprobe"/Wienna driving test

The „Wiener Fahrprobe" (Risser & Brandstätter 1985) is an observation method used by either one or two persons inside observed subjects` cars, in order to assess these subjects` behaviour. Several behaviour variables are registered. Driving behaviour is registered both in a standardised and non-standardised way (= non-predictable events). The total set of variables is meant to be a reflection of the observed subjects´ driving behaviour, or driving style (see Lajunen et al. 1998). Changes in driving behaviour that are expected from any measures, or brought about by any other changes of the preconditions for driving, should be reflected by changes in these variables. The original idea behind the Wiener Fahrprobe was that it should be used as an instrument to analyse driving behaviour in order to make sure whether a person is apt for driving a car or not (Risser 1985). Work was based on earlier approaches to achieve this, e.g., the different versions of Quenault`s driving-test (see Klebelsberg 1982), the Kölner Fahrverhaltenstest (see Kroj et al. 1973) and other more or less well known, and more or less structured instruments.

<u>Interaction & communication</u>

In the mean time, the concept of behaviour has been expanded, most of all in order to include interaction and communication aspects (Chaloupka, Risser & Roest 1991). The main assumption thereby was that isolated individual behaviour, steered by physical stimuli and by internal variables (thoughts, motives, opinions, attitudes) is not the only, and far from the most important, aspect from a psychological perspective. Communicative aspects (contingent reinforcement by the social environment, communication clusters that develop in connection with the distribution of power, imitation, etc.) most probably influence car driver behaviour to a very high degree. For example, due to the fact that the Wiener Fahrprobe so far was used mostly in urban areas, we focussed very much on the interaction between car drivers and vulnerable road users, especially pedestrians (see Chaloupka, Risser & Roest 1991).

As we know from literature the use of ITS systems has many impacts on driving behaviour. Evaluations of such systems like STORM (Stuttgart Dual Mode Route Guidance), ACC (Adaptive/Autonomous Cruise Control) or AAP (Adaptive Accelerator Pedal) showed, that there also exists an impact on communication and interaction between the observed car driver and other road users. Therefore the „Wiener Fahrprobe" is an appropriate tool to study impacts on behaviour directly in the field.

i Focus groups

Market researchers began using focus groups in the 1950s. They realised that many consumer decisions are made in a social context, often growing out of discussions with other people. By using focus groups market researchers gathered more accurate information about consumers' product preferences (see Patton, 1980 or, much earlier, Merton 1956).

The participants of focus group interviews can either be selected to constitute a relatively homogeneous or heterogeneous group of people. This depends on the aim of the interview. If one wants to collect different points of view of one and the same group then one looks for a relatively homogeneous group of people. If one wants to gather a broad range of arguments, pros and contras of a topic, conflicting interests, etc., an inhomogeneous group of people may be better, as one gets controversial opinions. In general focus groups are conducted with people who do not know each other.

The participants of focus group interviews are instructed to reflect on the questions asked by the interviewer. Participants get to hear each other's responses. Due to this fact participants usually make additional comments beyond their own original responses. For the group it is not necessary to reach any kind of consensus. The object is to get high-quality data in a social context where people can consider their own views in the context of the views of others.

With the help of focus group interviews one can also develop and prepare questions (e.g. for a quantitative verbal-data collection) and hypotheses, that are later investigated in detail.

Advantages of Focus Group Interviews
Focus group interviews have several advantages.

- They are an efficient qualitative data collection technique
- They allow aspects to come up that the conductor of a study has not thought of
- In just a little more than one hour the interviewer can gather information from eight people instead of only one person ✍ the sample size can be increased significantly
- The group situation enhances answers concerning even difficult situations and emotions
- There is a valuable quality control on data collection as participants tend to check each other's statements ✍ increase of credibility
- The situation is usually experienced as highly motivating by the participants.

Weaknesses of Focus Group Interviews
There are also some weaknesses of focus group interviews.

- The amount of response time to any given question is increased considerably ✍ there is a limited number of questions that can be asked
- It is always possible that unexpected diversions occur in a focus group interview ✍ conflicts may arise (although conflicts may give an insight into deeper-lying attitudes towards certain issues)
- When participants in a focus group do not know each other, it is difficult to guarantee confidentiality

Scopes of Focus Group Interviews
Focus group interviews can be used at any point in the evaluation process.

- They can be used as preparation for a standardised questionnaire, in order to gather all relevant information about a topic
- They can be used as additional qualitative evaluation method next to others.
- They can be used as single method to gather qualitative information about a topic, e.g. in order to understand certain psychological and/or social processes.

To sum up: Focus Group Interviews are usually a cheap and a fast way to identify the main aspects of a certain topic and to formulate assumptions that then can be analysed with appropriate methods, later-on (see e.g. Atteslander 1995, Krueger 1994, Bewyl 1992, Merton et.al. 1956, Morgan & Krueger 1998)

i Checklists

Checklists are tools that guide the users attention along points and aspects that should be considered when thinking about any process, how the process should be steered, what should not be forgotten, what steps should be taken, etc.
The checklist on traffic safety is a tool developed already at the beginning of the nineties in the frame of activities of the PROMETHEUS PRO-SAFE group. Literature and expert know-how was summarised with respect to behaviour adaptation, and transformed into questions. It focuses on the possible consequences for road safety by introducing new equipment in road traffic. It is a prognostic instrument and allows the formulation of assumptions concerning the effects of new equipment in road traffic. It can be used as a guidance and learning tool for constructors and experts. Using the checklist enables planners to systematically develop hypotheses concerning the influences new equipment

might have on road users` behaviour. Based on "intelligent hypotheses" it will be much easier both to develop prognoses and to decide how to assess the quality of these prognoses (see among many others Turetschek 2004, Ausserer & Risser 2005).

i Expert work in workshops

The concept of "workshop" implies to make various disciplines and professional groups related to the covered subject work together. In the case of traffic and mobility issues, the participants might be architects, town planners, engineers, psychologists/social psychologists, sociologists, public decision makers, territorial authorities, transport companies etc., and that on all the levels of governance. The methodological approach in workshops where discussions and group work take place is a **heuristic one**, appropriate for analysing a relatively unstructured universe of activities that are neither strictly theory-steered nor systematically knowledge- or rule based: Much work is unreflected routine, intuitive, steered by hidden agendas, following "private" hypotheses, done in the frame of certain schemes of distribution of power on the working place, etc.. The internal logic of such a system should be made better transparent with the help of heuristic methods:

From the psychological point of view, this concept (which comes from the Greek *heuriskein* = to discover, to find) covers the means of discovery and innovation. It is an intellectual *modus operandi* by open but active systems, for self questioning, problem solving, and plausible reasoning. It is also (in the field of education) a strategy of training by discovering (Bruner 1996). The heuristic method is based on the "*divergent production of the thought*" (Guilford 1975) and on "the fluid intelligence" concept developed by Cattell (1934) and used more recently by others (Garcia. 1991). *The heuristic method is different from an algorithmic one* since it does not prescribe fixed rules of operation but it cultivates the free combination of thoughts and admits several solutions. It requests imagination and the creative thought by *mechanisms of analogy, personification, analysis by synthesis, transposition.*
In the context of workshops, the goal is thus to enhance the construction of new ideas and the clarification of habits and practices not structured consciously, by being confronted with unusual questions and by making use of working methods or practices that do not belong to everyday routine. This justifies also the fact that the participants are rather not informed in advance of the detailed questions with which they are going to be confronted (which sometimes causes frustration or criticism from them).

The heuristic approach is also the basis of the principal criterion of selection of the participants, and of the composition of small working groups. The workshop is usually given a structure that allows multiple **feedback and interactions** between participants, but also between the participants and the organisers, making it possible for each one to enrich his/her conceptual field by the contribution of the others and to work out a collective thought step by step. In the methodological organisation, the plenary sessions constitute the major elements of collective synthesis of small-group reflections (see also Petica et al. 2003, Kölbach 1998, Klebert et. al. 1985)

i Qualitative interviews

In-depth interviews are a qualitative assessment method. They are partly structured, require a format, follow a process and have to be recorded (handwritten or taped). In-depth interviews are used throughout research to determine individuals' perceptions, opinions, facts and forecasts, and their reactions to initial findings and potential solutions. They are an often underestimated technique of inquiry, because many researchers are reluctant to accept the qualitative nature.
In-depth interviews are used throughout research to determine individuals` perceptions, opinions facts and forecasts, and their reactions to initial findings and potential solutions.
In-depth interviews have several roles in program evaluation and market research:

- Obtaining evidence for a problem or issue;
- Exploring the boundaries of a problem;
- Identifying potential solutions;
- Managing the research process.

In-depth interviews are used primarily to gather opinions, but other purposes can be fulfilled as well. At the outset of research, interviews may be used to determine the spectrum of insights and biases which exist. This initial exploration also assists in formulating the problem to be solved (see Gunn 2001).

<u>In-depth interview variations:</u>

In-depth interviews can vary by the objectives of the research. The examples below show how these can vary:

- Paired / Coupled interviews, which are useful for gaining an understanding of particular behaviours or decisions which consumers usually make in pairs, e.g. husband and wife interviews about home improvements or car buying.
- Accompanied shopping / observations are when a researcher accompanies a respondent on a given activity, observing and questioning the respondent's behaviour as they proceed.
- Intercept interviews, when interviewers approach people in a public place such as a shopping mall, street, sports event, or similar - whatever is best for the research objectives. These interviews are ideal for cost-effectively targeting selected types of people, but the interviews must be short, as respondents are usually en route elsewhere.
- Business interviews, which are ideal for interviewing senior and/or very busy business people, as the respondents can discuss commercially sensitive information; be interviewed at their most convenient times and places; and be given the level of respect they may be accustomed to.

(see http://www.researchsolutions.co.nz/in_depth_interviews.htm

a Description of methods

i Observation „Wiener Fahrprobe"/Wienna driving test

Variables

With the help of the „Wiener Fahrprobe" in its original form four sets of variables are collected by two observers:

Standardised variables

These variables are more or less descriptive. They contain positive, neutral and erroneous types of behaviour. The list of standardised variables consists of those types of behaviour that can be specified and expected in advance to appear, in different well-identifiable modes. For example speed behaviour: on each section of any route it will be possible to say whether an observed subject drove with a speed below or above the speed limit. Other standardised variables are the use of the indicator, the accuracy of lane use, the distance to the preceding car, how driving in curves is carried out, etc.

Errors

Errors are events such as neglecting a stop sign, that represent a severe offence of the law and/or cause danger. An example for an error is that the driver almost hits a pedestrian who crosses the road off the pedestrian crossing; the occurrence of such an event at precisely this place cannot be predicted. Standardisation of the registration of such an event is therefore not possible.
Erroneous behaviour can lead to an accident, to a traffic conflict, or also pass without any problems, depending on circumstances, e.g., on the presence of other road users.

Interaction/Communication processes

As has been said, focus during the last years of development work has been very much on interaction/communication processes. For these processes it is quite typical that they are not well predictable, neither with respect to where they will appear, under which conditions and in which form they will appear, nor to say whether they will appear at all (see Risser & Hydèn 1993). At the same time it is utterly important to register communication processes.
In detail, interaction/communication processes are situations where other road users are present and the behaviour of one person produces stimuli for the behaviour of other persons. Positive (e.g. friendly) and negative processes (e.g. ruthlessness) can be observed.
To observe interaction/communication processes during a test ride allows best to describe the "social" context on the street: One is hardly ever alone on the road, or behaving independently of other road users.

"Communication" does not only mean plain information, it also means deliberate neglecting of rules, thus offending the others' rights and/or feelings which can lead to unwanted and/or dangerous situations.

Traffic conflicts

The traffic conflicts that the observed objects get involved in along the route are registered. A traffic conflict is an event where there is a collision course between two or more road users with a time to collision shorter than ~1 sec., and where an accident is avoided thanks to the evasive action (braking, swerving, or accelerating) of at least one of the involved road users. Types of conflicts are

- rear-end conflicts
- head-on conflicts
- left-turn conflicts
- right-angle conflicts
- lane-change conflicts
- right-turn conflicts
- conflicts with vulnerable road users

Procedure

The standardised variables are taken up by one observer, called the coding-observer, with the help of a standardised observation sheet. One sheet per section has to be filled in. Events of the described type are taken up whenever they happen. Absence of such events is not mentioned explicitly, so that for some of the observed subjects there might be no behaviour registration data for several sections of the standardised route.

Errors, interaction/communication processes and traffic conflicts are collected by the other observer, the so-called free observer. One sheet per event has to be filled in, the number of the section, where the event took place, has to be added.

The total set of variables, as said above, is meant to be a reflection of the observed subject's driving behaviour, or driving style. Changes in driving behaviour that are expected from any measures, or brought about by any other changes of the preconditions for driving, should be reflected by changes in these variables.

In practice, the actual registration of behaviour and interaction starts after 15 minutes of the observation trip, as literature about driver observation suggests that the presence of the observers is “forgotten" after some 10 to 20 minutes (Höfner 1972). The hypothesis is that it is not possible to hide types of behaviour that have been internalised (i.e. habits, automatised behaviour) for a long period. Driving a car involves, certainly to a high degree, many such types of behaviour.

The length of test route is usually between 25 and 50 km. This route includes densely inhabited areas, and to a lesser degree rural roads and motorways. A typical test route is divided into sections: Sections of road between intersections, intersections themselves, motorway entrances, and motorway exits. All parameters of the sections should be recorded, like speed limits, stop signs or yielding regulations. Between the peak hours, it takes between 40 and 60 minutes to drive along such a test route of usual length, depending on characteristics of the driver and on the usual fluctuations of the traffic volumes at different sites and along different routes. Observations with the help of the "Wiener Fahrprobe" are usually done on weekdays between the peak hours, for instance a series of observations at 0900, 1030, 1330 and 1500. The wish is to avoid peak hours, because otherwise it is very difficult to keep time schedules, and, in general, to take up errors other than short headways to the vehicles in front. Each observation should take place at nearly the same daytime, otherwise comparability will suffer.

i Focus Groups

The structure of focus group interviews

The focus group interviews can be structured either strongly or weakly. Both forms have advantages and disadvantages, which are discussed in the following description (see Krueger 1994).

Table 1 Strongly and weakly structured focus group interviews

	Advantages	Disadvantages	Question route
Weakly structured focus group interviews	Different perspectives are stated New ideas are brought up	Less target orientated To make a comparison between different groups is more difficult	Just a few questions the questions are a result of the discussion
Strongly structured focus group interviews	Clear answers for clear questions Makes a comparison between different groups easier.	Not an appropriate method in order to get new ideas	Many questions, Target orientated questions

The interviewer

For the focus group interview the interviewer prepares a rough script. He interferes only if it seems necessary to keep the interview going and to guide it in the right direction.

Facilitating and conducting a focus group interview requires considerable group process skill. The interviewer has to take care that the interview is not dominated by one or two people, that all participants are enabled to share their views, etc.

Table 2 Controlling-Possibilities for the Interviewer

Questions	Controlling with different kind of questions like starting-questions, key-questions or summarising statements
Breaks	"15-seconds"-breaks with the goal to provoke other statements
Deepening questions	Deepening questions from the interviewer after a statement like “Could you explain this in somewhat more detail?”
Body language	Eye-contact with shy participants Avoid eye-contact with participants who talk too much No statements from the interviewer like “Very good!” or “Excellent!”, no shaking of one’s head, no nods, because all this will influence the participants

How to record Focus Group Interviews

Focus group interviews are usually voice-recorded or video-recorded. In addition notes are taken. As it is difficult to take notes during a focus group interview while moderating the discussion, focus group interviews are usually conducted by two interviewers, with one person focusing on taking notes and the other focusing on moderation. The person who takes notes should also try to describe to some degree of the body language of the participants (i.e., try to interpret the feelings and attitudes of the participants: "hesitant", "angry", etc.). Good notes may suffice to describe what happened and what was said during the focus-group interviews, the recordings sometimes are only needed in order to make sure what was said if this is not clear from the written notes alone.

i Checklists

The checklist should reflect the traffic system in such a way that wished-for and non-wished-for traffic system aspects can be defined/identified. Based on this one can develop assumptions on what should be included in driver training. These aspects can be located in the different areas displayed in *Figure 7* “The diamond” (Risser, 2004)

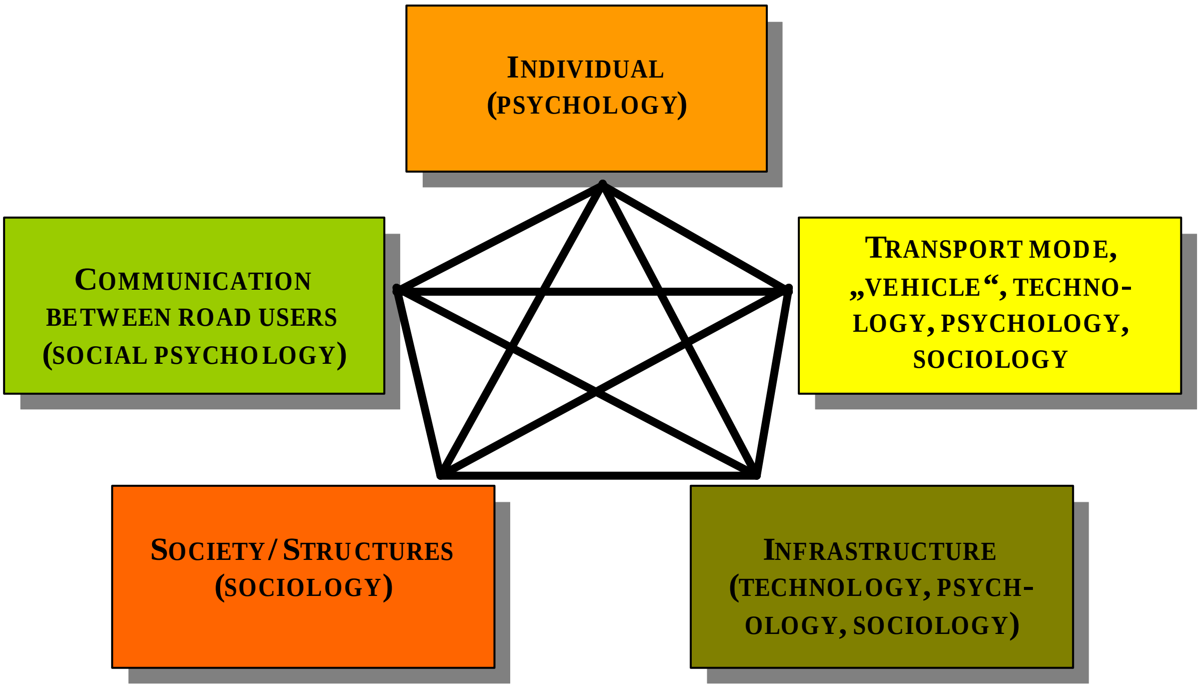

Figure 7 The diamond from Risser (2004)

In other words, the Checklist assists the process of developing expert prognoses, thereby considering the dimensions displayed right above.

The checklist takes into consideration both the physical and the social environment when systematically trying to assess the effects of any new vehicle or infrastructure ITS equipment. When used from a psychological or social-scientific perspective, all the changes will result as a consequence of changes in driver behaviour and interaction, which depend on the characteristics of the new equipment. One checklist that has been used at several occasions in order to assess the effects of new ITS, the PRO-GEN Traffic Safety checklist, in its primary version includes the following aspects:

- Characteristics of the equipment that should be analysed
- Technical/practical questions: how the equipment works

This topic includes questions like: What is the aim of the equipment in traffic? What should the equipment exactly do? Is the equipment purely advisory, or can it take control of the vehicle under certain circumstances? Is information transmitted in-car or from the road side?

- Functional and behavioural aspects: what are (road) users supposed to do

This part of the checklist asks for description and for specification, what the equipment does do in practice, how it interacts with the driver, and what types of behaviour are expected from the driver (from road users) in connection with the use of the equipment.

- Expected (and possible unwanted) impacts of new IST

«Impacts» refers to the effects/influence on perceptions and decisions, on behaviour and on interpersonal communication. In this connection, a short overview of some psychological aspects has to be given.

Many of the questions taken up in this checklist refer to expert assumptions: They are taken up in the checklist because experts, viz. their/our experience, have underlined these questions as being relevant. In many cases empirical evidence from the traffic area is missing, at first, but hypotheses can be formulated, that very often are based on psychological rules that have been empirically tested in other circumstances:

What could the consequences of new equipment for driver behaviour be, for instance? E.g., the safety gains might be compensated for by more risky behaviour, in some cases as an explicit goal, in the other cases as an outcome of the over-satisfaction of the need for safety.

The PROMETHEUS traffic safety checklist was developed in order to help experts to produce prognoses concerning the implementation and use of new equipment. Such prognoses should make it possible to evaluate new ITS at an early stage, concerning influences on perception, decision making and behaviour, possibly producing changes with respect to both traffic safety and traffic climate. This is of course relevant for the citizens' quality of life. If negative effects in this respect can be avoided by shaping behaviour in an appropriate way than this has to be considered an important task of driver education.

i Expert work in workshops:

Individual presentation

The participants at workshops usually arrive at the site of the meeting without knowing each other, and without really knowing which would be the procedure thereafter. Work quite often is started with an individual presentation of the participants. Such presentation has advantages on at least two levels:

- It helps first of all to relax the atmosphere and to give to each person a first outline of other participants in the workshop. Each one should note that the others are rather interested in a certain topic. This makes it possible to start to build confidence between the participants. To establish this confidence is one of the primary objectives, so that each participant can freely express his/her ideas and opinions, without being afraid to be questioned in his/her competence as an expert.
- It makes it possible to carry out a first review of the contents of the topic in the frame of co-understanding and co-operation. In this context, participants are confronted with, possibly, unusual ways (to them) to deal with problems (cf. heuristic method).

The organisers collect notes and record the debates for reporting. The collecting of notes is best done with the help of video, which allows a follow-up of the presentations by all the participants.

Discussion in small-groups

The discussion in small-groups has primarily two functions:

- On the one hand, it allows all to express themselves on the subject: with respect to this, the maximum number in small groups should thus be limited to 6-7 people, which establishes the size of a "small group" per definition. In order to try to make everyone take part and not to lose sight of the required work, each small group should indicate a leader and a secretary.
- If one wants to confront participants with expert opinions that probably differ from one's own, the composition of the small groups can be established in order to have the maximum of variety in the points of view.

The small groups should make a first synthesis and thus reduce the diversity of factors linked to the discussed concepts – they should try to reach some consensus.

Plenary

The plenary sessions have three main functions:

- to steer the structure of the collective work; the chairing persons give the instructions of work during the plenary sessions
- to present results of small-group work, and to receive feedback: each small group thus has access to the results of the work carried out by the other small groups. To reinforce that, at the end of the first working day the workshop organisers may produce a summary of the sessions held during that day. This summary can be communicated at the beginning of the plenary session in the morning of the next day. This allows the participants to quickly recall the principal ideas and get on track for the continuation.
- to be a place of synthesis, allowing to work out step by step the given topic: the presentation of work should be relatively short (10 minutes), for reasons of timing (e.g., 10' X 5 groups = 50 minutes) but also to oblige the small groups and their speakers to really make this effort of synthesis.

From the organisational point of view, the organisers should record all the plenary sessions on video, to be able to secure all significant elements and not to lose valuable information. For a workshop it is necessary to have a clearly defined aim. You need a moderator, who leads the whole workshop (see e.g. Petica et al. 2003, Kölbach 1998, Klebert et. al. 1985).

i Qualitative interviews:

Interviews should begin with general questions. Interviewers must have a certain experience with the topic, they should be able to build an interpersonal situation to gain people's confidence and be good listeners, as well. Interviewees should talk 90% of the time, as a very rough rule of thumb, in order to provide a coherent overview of their thoughts.

At an early stage of a system assessment, less structured interviews – if carried out in connection with development and/or use of IST - may serve to identify more clearly certain system requirements. Motivation for use, or resistance against, certain market products can be determined.
In-depth interviews take time, but usually they help to make hypotheses about possible effects of any measure much more accurate. Our assumption is, thus, that they help to save money, when it comes to predicting and controlling road user behaviour, and to avoiding non-wished-for side effects (see e.g. Guion 2001, Gunn 2001).

a Specific Human Centred Design components in the methods

The HUMANIST objectives' description contains, among other arguments the following: "The effective realisation of the expected benefits (of new ITS) is going to depend on conditions of systems implementation: in particular, in which measure the system responds to drivers needs, is compatible with their functional capacities and satisfies the criteria of relevance, usability and acceptability. … the emergence of automation technologies, that is assistance systems being able to take care of some control tasks traditionally assigned to the driver, brings the problem of the tasks dispatching between human and machine, as well as the choice of the logic used for the management of this control sharing, substitute or co-operative. Particularly in the case of co-operative assistance, further research is needed regarding the emergent human driving tasks of system supervision, system status awareness, and system response representation.

All this argues for a more active participation of the Human Sciences in the various stages of systems conception and for a concept of technological development determinedly centred on Humans, in which the assistance is designed according to the needs and the capabilities of the human being and not driven by the technological offer. When, in the end, the systems will be able to modulate their assistance according to the analysis of the driving situation requirements, one can then speak about cognitive engineering, where a correct matching between the system design and the specificity of human being is ensured, for positive consequences in terms of road safety."

In all of the above mentioned methods humans and their behaviour (Wiener Fahrprobe, Check list), their attitudes, needs etc. (Focus Group, Workshop, In-depth interviews) are in the focus of the research.

As users themselves do not design or implement any product, scientific researchers have to provide information about user needs and researchers, planners, technicians, policy makers etc. have to translate the obtained information to the product design and the envisaged use of a telematic product in order to be successful.

The graphic below (Figure 7) exemplifies areas in which these methods can be used. It underlines the complexity of the planning, producing, implementing and evaluating procedures and the importance of using different scientific and human centred design methods. Certainly methods of other disciplines have to be included in the different steps but we focus on the social scientific methods as tools that are essential in connection with human centred design.

According to marketing strategies it is essential in the planning phase to get to know everything about the target group (Information policy = human centred with respect to the target group; Kotler et al. 1996). Qualitative methods like Focus group interviews (FGI), In-depth interviews, partly driving observation methods, and Workshops have the potential to support finding out more about user needs, perceptions, attitudes etc. During the development of a product one has to make sure that the product is adapted to the user needs (Product Policy) which can be evaluated with the help of qualitative interviews and quantitative methods like standardised surveys and partly driving observation methods. During the implementation phase one may try to enhance acceptance and appropriate use by giving incentives and by communicating the advantages of the new product (Incentive & Communication Policy = I & C Policy). For example expert workshops help to develop recommendations and hints what kind of aspects have to be considered in this respect. Finally it has to be evaluated with the help of qualitative as well as quantitative methods if the product actually meets the needs of the users (quality assurance) and of society (e.g., traffic safety, environmental criteria). If the product does not fulfil the expectation of the users one has to find more about the user needs which brings you back to the beginning.

Figure 8 Production, marketing and related research methods or production, marketing & method circle

The circle should make it clear that social scientific methods always have to be used in combination. Quantitative instruments have to be prepared by earlier qualitative work, theoretical and empirical. So even the Wiener Fahrprobe can be used to prepare a standardised questionnaire. On the other hand methods like Workshops and FGI are quite appropriate for carrying out quality assurance of the results that have been gathered with the help of standardised methods. If you discuss the results of quantitative studies with experts you get valuable information for the final implementation that in principle is the result of a heuristic approach.
Furthermore, the interests of different user can be made transparent with the help of social scientific methods, and instead of remaining hidden, conflicts of interest become visible and can be treated.
With respect to the Wiener Fahrprobe it can be said that not only the driving behaviour of the test person can be evaluated but also the communication with other road users which is a key issue in traffic, reflecting safety, social climate, informal rules, etc.

a Towards Human Centred Design methods

More and better combination of qualitative and quantitative methods is needed. As said before FGI, In-depth interviews and Workshops can easily be used as a preparation of quantitative instruments. The results of a quantitative study should be discussed in the frame of a workshop to assure that suggested measures, are convertible.

The effects of telematic systems on the driver (behaviour, distraction) should be evaluated with qualitative methods as with the help of these methods the effects of systems on the driver could be elaborated more easily and in more detail.

What is missing is in principle and integrated methodology and guidelines for the use of the tools included there: experts should not only know the potentials of their own favourite methods and procedures, but are open to combine methods, according to the state of the art.

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7. REVIEW OF THE HASTE-METHOD

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a Project

HASTE - Human Machine Interface And the Safety of Traffic in Europe. Project GRD1/2000/25361 S12.319626 research project (2002-2005). This project was supported within the specific programme Competitive and Sustainable Growth and is in specific response to Growth Task 2.2.5/6 - Development of methodologies and performance measures to assess long term safety implications of new in-vehicle technologies including HMI for road transport.

The aim of HASTE was aimed at the development of a valid, reliable and efficient tool for aiding testing authorities in their safety evaluation of IVIS. The partnership consisted of eight European partners and one partner from a country with a cooperation agreement:

- University of Leeds
- MIRA Ltd
- Swedish Road and Transport Institute (VTI)
- TNO Research Institute
- TRAIL Research School
- Transport Canada
- University of Minho
- Volvo Technology Corporation (VTEC)
- Technical Research Centre of Finland (VTT)

a Purpose of method

The purpose of the method developed within HASTE was to assess the safety impact of In Vehicle Information Systems (IVIS). The aim of the project was to develop a method that can be applied in the IVIS/ADAS design process in order for the manufacturer/developer to assess the safety impact of the product on driving. But the method was also designed to be used after market introduction by e.g. test authorities. For details about the HASTE method see (Östlund et al., 2004 and Östlund, 2004).

a Description of method

The HASTE-method focuses on effects of distraction on the regulating and monitoring level of the DVE-model. Thus, no positive effects such as found for ESC or navigation systems are evaluated by this method. However, there is no specific restriction for this in the method, that is why it is reasonable that also positive effects, on monitoring and regulating levels, can be identified with this method. ADAS, including assistance and warning functions, is not originally within the scope of this method.

The method is based on simulator experiments including rural road driving and a set of participants. The rural road includes straight and curved road sections, and a lead vehicle always present. Several driving behaviour measures based on vehicle measurement are included, e.g. speed variation, lateral position variation and headway. Also, a subjective measure, reported by the participants, is included.

a Specific Human Centred Design components

The HASTE-method includes evaluation of driving performance, in this case risk of accident. The method can discriminate between negative effects of distraction originating from visual load and mental workload to some extent, so it may be possible to identify what qualities of the tested IVIS/ADAS need to be redesigned – if driving performance is found to be affected negatively by the IVIS/ADAS.

a Towards a Human Centred Design method

The HASTE-method does not yet include a systematic test procedure. However, scenarios, driving performance indicators, analysis method and characteristics of experiment participants are defined.

Although the HASTE-method is applicable also on ADAS, it has only been validated for IVIS. The same goes for *positive effects* of IVIS and ADAS; the focus of the method is negative effects of visual and mental load. However, the method can still be complemented to include also positive effects.

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• 8. REVIEW OF THE OCCLUSION METHOD FOR ASSESSING VISUAL DEMANDS AND INTERRUPTABILITY OF IVIS TASKS

Anke Mogilka (CUT) & Martin Baumann (BASt)

a Project

The occlusion method (Baumann, Keinath, Krems, & Bengler, 2004; Keinath, Baumann, Gelau, Bengler, & Krems, 2001; Noy, Lemoine, Klachan, & Burns, 2004) has been evaluated in several research projects at Chemnitz University of Technology (CUT):

- in a joint project with BMW on the suitability of the occlusion method for evaluation of information presentations while driving (2000-2004)
- in a joint project with the Federal Highway Research Institute (BASt, Germany) on skill acquisition when interacting with IVIS (2000-2003)
- in the German national project ADAM (Baumann, Rösler, Jahn, & Krems, 2003; Breuer, Bengler, Heinrich,& Reichelt, 2003)
- in the IHRA-ITS Swedish-German Study on method development (2000-2003)
- in a joint infrastructure-sharing project within HUMANIST together with BASt and TRL (2005)

a Purpose of method

The occlusion method has been proposed as an easy to use, cost and time-efficient method for assessing the visual demands that the Human Machine Interface (HMI) of In-Vehicle Information Systems (IVIS) places on the driver. Recently, the method has been also proposed for evaluating IVIS' tasks interruptability. The method has a high face-validity, simulating the shifting of the drivers' visual attention to the road scene (primary driving task) and to the visual display of an in-vehicle system (secondary task). The major aim is to measure performance on an IVIS task while being disrupted in a manner similar to normal driving conditions. For interactions with in-vehicle systems it is essential that the driver can perceive and interpret relevant visual information within an acceptable short time scale in order to avoid long glances away from the road scene (minimise visual distraction). Furthermore, dialogues with an in-vehicle system must be easy to interrupt and resume without additional effort on the part of the driver, so that he/she is able to freely adapt his/her intentional focus to the changing demands of the driving task. The occlusion method is intended to be used by manufacturers/system developers in the very early stages of system development.

a Description of method

The occlusion method is based on the systematic control of the permitted time intervals for a participant to look at a scene. The two essential parameters are the period during which the relevant piece of information is visible (viewing or presentation time) and the period during which it is not visible (occlusion time). In the system-paced variant the viewing time and occlusion time are controlled in predefined cycles, and the accuracy and quality of the information gathered can be used as a measure of performance.
Usually, values of 1.5 – 2 seconds are used for 'shutter open time' (the duration of a single viewing interval), and 1.5 – 3.0 seconds are used for 'shutter closed time' - the duration of a single occlusion interval; (Baumann et al., 2004).
The occlusion method can be used to evaluate sequences of interactions with graphical interfaces of in-vehicle information systems (e.g. entering destinations into a route guidance system, searching for phone numbers in an address list etc.)

Terms:
TSOT: Total shutter open time. The sum of the all shutter open intervals until a task is completed.
TTT_{base}: Total task time baseline. The total time needed for task completion under baseline conditions (without occlusion spectacles).
TTT_{occl}: Total task time occlusion. The total time needed for task completion under occlusion conditions.

a Specific Human Centred Design components

The occlusion method is suitable for filtering out poorly designed interfaces during the evaluation phases of user interface prototypes and system prototypes.
The method needs tests with human subjects.

The occlusion method can give information about the visual demands of a driver's interaction with an IVIS, and about the proportion of time a task can be performed without visual information acquisition (blind operation). Tasks with short Total Shutter Open Times (TSOT) may still involve considerably mental effort (evaluation of system feedback, planning ahead, developing strategies for directing visual attention, recalling dialogue options/information position etc.) during the shutter closed intervals which are not expressed in task performance durations. In order to derive more valid conclusions a cognitively demanding loading task is recommended for the 'shutter-closed' intervals.

a Towards a Human Centred Design method

- The occlusion method is applicable in the early stages of system design.
- It has the potential to separate between very well designed and very poorly designed systems with regard to visual demands.
- The occlusion method is sensitive for visual demands, but insensitive for cognitive demands (e.g. working memory load, demands for planning).
- The method provides an absolute criterion of visual demand (TTT_{occl}/ TTT_{base}).
- In order to improve the methods validity, a cognitive demanding loading task should be implemented during the 'shutter-closed' intervals
- The method is suitable for identifying interactions which support blind operation
- Disadvantage: System delays (when they occur during shutter closed intervals) may be indistinguishable from effects of blind operation.
- The method is applicable to any kind of visual interaction with IVIS of a certain duration (thereby involves several shutter-closed & shutter-open cycles).

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• 9. REVIEW OF ASSESSMENT TOOLS FOR ADAS ACCEPTANCE BY USERS

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a Project

The method describe below was developed in the ADVISORS project

a Purpose of method

The purpose of the method described here is to capture the opinion and acceptance of ADAS systems among different user groups by interviews. The results are then analysed in order to understand how different user groups conceive the utility of prospective systems.

a Description of method

Interviews

The key factor for future implementation of the ADAS systems is the acceptation by its end users. The problem is that different users have different opinions on how to use and adopt these systems. The acceptability of a system further affects **end-users'** willingness to pay for such systems, and determines the overall effects of the systems on e.g. traffic safety. The second actor group having a major impact on the implementation of ADAS systems is **vehicle and system manufacturers**. They have the greatest knowledge of the technical possibilities and feasibility of the systems. On the other hand, their product development is driven at least partially by marketing studies telling them what end-users want, and what are they willing to pay for the new systems. Furthermore, manufacturers are dependent on legislation and are actuated by the responsibility issues. The third actor group playing an important role is **the authorities and administrations**. They are expected to maintain the welfare of the society and must therefore consider new system implementations and impacts of new technologies on the society as a whole, considering all the possible impacts of the new systems - both for users and non-users. They have the possibility to affect the implementation of new systems through legislation and information directing user opinions (Mankinnen et al., 2000).

The purpose of this method is therefore to investigate opinions and attitudes of users towards ADAS. The interviews can be conducted by telephone, face-to-face or by filling-in a questionnaire. Each version of the interview should be created considering the way of data collection. If collecting data by telephone, a list of relevant issues the survey is dealing with should be forwarded to the participant in advance. Face-to-face method seems to be very fruitful if documenting additional comments of the respondent.

The questionnaire is divided in 2 parts. The first part, on one hand, deals with the present traffic problems of the country's respondent lives in; i.e. road network capacity, travel time, public transport accessibility, traffic safety, traffic noise and emissions). On the other hand, the participant is asked to estimate all these problems in the year 2010. All questions were close-ended, so that they could be answered by providing only one rating (1-10; 1 negligible, 10 extremely important). Second part is focused on selected ADAS (i.e. ACC, speed control, collision avoidance). The participant is about to estimate, which ADAS systems are most desirable to be implemented in year 2010 in his/her country. The function of each system is briefly described.

Users of the method: manufacturers/developers of systems/vehicles, public authorities, administrations, legislative bodies

Conjoint analysis

Conjoint analysis is a multivariate technique used specifically to understand how respondents develop preferences for products or services. Utility, which is the conceptual basis for measuring value in conjoint analysis, is a subjective judgement of preference unique to each individual. Utility is assumed on the basis of the value placed on each of the levels of the attributes and expressed in a relationship reflecting the manner in which the utility is formulated for any combination of attributes.

A set of real or hypothetical products or services by combining selected levels of each attribute is created by the researcher and then these combinations are presented to respondents, who provide only their overall evaluations. The respondent is about to choose from variety of products and makes a decision which product is worth to buy. Respondents need not to tell the researcher anything else, because the researcher constructed the hypothetical products or services in a specific manner. The influence of each attribute and each value of each attribute on the utility judgement of a respondent can be determined from the respondents' overall ratings.

Advantages of conjoint analysis are: a coherent view on evaluation of alternatives and decision making is provided; registers preference and choice behaviour in marketing and service industries; a well-developed set of research tools is available to make the data operational. Limitations of conjoint analysis are: uncertainty about the relationship between preferences and choices made by individuals in experiments and their real-world preference and choice behaviour; participants are not familiar with the innovative systems; hence, it is uncertain if individuals will be able to understand and evaluate the systems properly (Mankinnen et al., 2000).

Users of the method: manufacturers/developers of systems/vehicles, public authorities, administrations, legislative bodies.

The framework of the project used the classification of key and other important actors.

Classification of all the relevant actors
Classification of all relevant actors influencing the traffic system as a whole included two steps. First, the actors were classified into seven main categories: users of the systems, other road users, industry, authorities and administrations, enforcement and inspection, traffic and transport operators and other. Due to different background and responsibilities in the traffic system, the groups were assumed to have different points of view of the existing and future traffic-related problems and the future of several ADAS systems. Second the main categories were classified into subcategories.

Selection of key and important factors
The actors who either have an extensive knowledge of the traffic system and its problems or who can have a great influence of the implementation of ADAS systems were defined as the key actors. The actors who also have a wide knowledge of traffic-related problems and who can influence the implementation of ADAS systems a great deal, but who have different background than the key actors were defined as "other important actors". The classification of the different actors is presented in ***Table 3***.

Table 3 Classification of actors

Main classification	Subgroups		
1. Users	1a) Drivers	Private	young/adult/elderly male/female drivers with special needs (e.g. handicapped)
		Professional	• Bus/coach Truck/lorry Van (delivery) Taxi Car (sales persons)
	1b) Umbrella organisations	• *consumer (ANIC)** *private driver (AIT, FIA etc.)** *public transport associations (UITP)** *trucking associations** *taxi associations **	
2. Other road users	drivers without the system vulnerable road users		
3. Industry	**system manufacturers**** **vehicle manufacturers**** infrastructure providers service providers		
4. Authorities/ administrations	*EU** *Governments, policy makers (vehicles) ** **Transport ministries**** **road authorities**** telecommunications		
5. Enforcement/inspection	police vehicle inspection/ monitoring		
6. Traffic/Transport operators	**fleet managers**** *road operators**		
7. Other	EU/ISO standardisation bodies *Insurance companies** lease companies *car rental companies** *researchers and consultants**		

Functionalities of ADAS covered with this method
These types of ADAS were assessed by interviews and conjoint analysis:

- Emergency calls
- Speed control, intelligent speed adaptation
- Collision avoidance
- Driver status monitoring
- ACC/ICC
- Road surface monitoring
- Vision enhancement
- Lane keeping
- Platooning/road train
- Stop and go assistance
- Vehicle following assistance

a Specific Human Centred Design components

The methods for assessing ADAS by users (including interviews and conjoint analysis) need testing with human subjects. The results can be used as input in the user needs analysis and system requirement definition.

a Towards a Human Centred Design method

- interviews and conjoint analysis may be applicable in the stage before going on the market
- methods used in the ADVISORS project have a potential to find out end-users willingness to pay for ADAS systems, and can determine overall effects of such systems on traffic safety
- limitations of the conjoint analysis are: uncertainty about the relationship between preferences and choices made by individuals in experiments and their real-world preference and choice behaviour; participants are not familiar with the innovative systems, hence, it is uncertain if individuals will be able to understand and evaluate the systems properly.

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• 10. DISCUSSION

A theoretical model can contribute in many ways during a design process. However, it is more or less an impossible task to come up with a model that is both sufficiently comprehensive and detailed covering all aspects of such a complex task as driving. Many attempts have been made to model driving and even if the perfect model has not yet turned up most of the models have contributed to a better understanding. Industry, authorities and end users (drivers) can all profit from the technological development even if the three can have somewhat different objectives. However, the overall goal since many years is to promote safe and sustainable (e.g. harmonisation with the environment) mobility for the citizens. Given that we have a theoretical model or framework of driving or subsets of the task it can be used in several ways in the design process of new technology in cars like IVIS and ADAS e.g.:

- better understanding of the problems new technology aims to solve
- input to the design of systems aiming at solving the identified problems
- better understanding of potential dangers with new technology
- input for the implementation of built in adaptive functions
- developing evaluation methods and tools to investigate new design
- input for producing information to the end users in terms of functional descriptions
- developing functional metaphors that can be used in the design process to promote a common understanding among system developers

The DVE model as developed in the AIDE project was based on very generic Cognitive Engineering research, e.g. COCOM and ECOM. During a review process in the AIDE project it was considered as the most promising model or theoretical framework at hand for project purposes i.e. develop improved (adaptive) IVIS and ASAS system together with relevant evaluation methods and tools that can be used in an industrial process environment (vehicle manufacturers). This modelling work is described in the second chapter of this deliverable.

However, as previously stated, so far we have not seen the overall perfect theory and critical review of the DVE will hopefully improve our understanding of driver behaviour and the driving task. Recent neurological research using new technology by e.g. Damasio (1994, 1999, 2000) has shown the impact that our feelings have on our decisions and behaviour. The impact of feeling has more or less been neglected in the past partly due to the difficulties in quantifying these dimensions of human behaviour. Based on this new research the proposed DVE model is criticised in chapter three with the vision of developing a better understanding of human behaviour in relation to new technology. However, the author does not present a full-blown alternative to the current DVE model and given the fact that the DVE has not yet been tested it is seen as immature to abandon the DVE at this stage. The criticism should not be viewed as a first step towards something new based on a slightly alternative view of what determines our behaviour while driving. Even if we now can recognise the impact of feeling on behaviour it is not yet feasible to let technology adapt to our feelings while driving.

The next chapter describes some fundamentals of the design principles that were developed in the realm of Human Computer Science back in the 80ties. The new computer based technology was far more flexible and challenged our cognition of the systems developed. The functionality became much more obscured to the end users. The designer and developers were not always familiar with the reality of end users. Features were often implemented just because the technology allowed for it. Users became frustrated and they did not understand how the system functionally worked. Users had a very different view of the system compared to those who implemented it. Flexibility can provide freedom but also confusion. Vast examples of badly designed devices can be found in Don Normans book "Design of everyday things" (Norman, 1998). Whether the success story of Apple's concept WYSIWYG ("What You See Is What You Get") and other guidelines (see below) was pure luck or a carefully planned and conducted design is unclear but it certainly was a major breakthrough in the HCI area which proved the benefit in considering the end user and the application of a Human Centred Design.

Apples basic guidelines for User interfaces
From Human Interface Guidelines for the Apple MacIntosh.

- Metaphors from the real world
- Direct manipulation.
- See- and -point (instead of remember- and type) Command based language and icon based operations.
- Consistency
- WYSIWYG (What you see is what you get)
- User control
- Feedback and dialog
- Forgiveness
- Perceived stability
- Aesthetic integrity

The message is in simple words: “Include the user all along the design process from the initial idea to final product and realise that a useful product is developed in an iterative process with consecutive evaluations and redesigns!” Even if the situation has improved to some extent there still seems to be work that needs to be done. Let me give an example. In a very early car model a series of lamps had been installed on the dashboard to indicate the firing of the sparkplugs. Maybe the information was very relevant to the technician but not very relevant to the driver and possibly even disturbing. Looking to day in e.g. Toyota Prius there is a display placed centrally on the dashboard which gives information about whether car is running on electricity of liquid fuel. Technically very interesting but is this really a response to the drivers needs? Thus, it seems like the involvement of end users can improve in order to get both safer and more useful systems in our cars which are a true support and not another fancy gadget we have to adapt to. The chapter gives some tentative ideas on how to involve the user in the design process. Specifically, concerning the use of different evaluation tools in the process. Finally, it might be worthwhile to reflect over the five fallacies or “the road to bad design” as described by Pheasant (1999).

- No. 1 This design is satisfactory for me - it will, therefore, be satisfactory for everybody else.
- No. 2 This design is satisfactory for the average person - it will, therefore, be satisfactory for everybody else.
- No. 3 The variability of human beings is so great that it cannot possibly be catered for in any design - but since people are wonderfully adaptable it doesn't matter anyway.
- No. 4 Ergonomics is expensive and since products are actually purchased on appearance and styling, ergonomic considerations may conveniently be ignored.
- No. 5 Ergonomics is an excellent idea. I always design things with ergonomics in mind - but I do it intuitively and rely on my common sense so I don't need tables of data.

The development and current pros and cons of the European Statement of Principles (ESoP) are described in the next chapter (5). The ESoP can to some extent be considered as equal to a standard however the ESoP provides guiding on a higher and more generic level. One of the real benefits is that standards are usually accepted by the industry, specifically if they can influence/control the content of the standard and this seems also to be the case for the ESoP. Standards aim at making things similar or rather interchangeable. This will simplify the production and hopefully reduce costs but on the other hand it will reduce the freedom of design. Standards can also be used to promote usage and decrease the risk of human errors, mistakes or what ever we call them. The manufacturers love standards as long as they do not interfere with their freedom to further develop and to make the products unique in some sense, e.g. it is important that driving a Mercedes should feel different from other cars! Standardised interfaces like the position of accelerator, clutch and brake pedals are obviously promoting usefulness and safety. However, no one can present evidences that this design is superior to alternative – the benefit is the actual standardisation. Here is a recent example in order to highlight the difficulties with standards. Several accidents in buses are related to the doors; passengers get stuck both inside and outside the bus. Both minor and fatal accidents have been reported. Accident investigations have shown that malfunction or errors made by the drivers cause these accidents. There is a ISO standard for the design bus drivers cab in city buses with respect to where to position different functions on the dashboard but the door opening functions and the actual layout of button and signals are not standardised. A standard for door function and physical layout of the door controls and signals were presented to the manufacturers who responded that such a standard would interfere too much with their design freedom and asked for proof that the proposed design would solve the identified problems before they could consider the proposal.

So the task from the user's perspective is to promote usefulness and thus safety and at the same time not restrict the further technical development. Technical development can of course benefit both users and producers. Even if the ESoP allow a freedom of development by the high level recommendations it has several limitations as described in chapter five e.g. no measurable criteria, principle can have exceptions etc.

Furthermore, there are some limitations in the scope of the ESoP, e.g. main focus on system with an "explicit" interface to the driver (i.e. IVIS), ADAS not considered to any extent even if there are principles that apply, and some specific interfaces are not considered (e.g. head-up displays, night vision and voice controlled systems). ADAS type of systems can be considered as having a more intrinsic or direct interface as they more directly interact or influence the actual behaviour of driver. IVIS types of systems provide more of decision support to the diver and thus the transfer of information to the driver will require a more explicit interface like a display.

In summary it seems like even if the ESoP need to be further developed in several aspects they are very useful in the design process of both IVIS and ADAS. Probably they will develop by time and use e.g. as the use of ADAS and IVIS become more common there is a chance to get valuable feedback on actual implementations in terms of usefulness and safety. However, searching for the truth should not prevent the application of a principle as the actual conformity to the principle might be enough even if the real truth was not revealed. Freedom can be a costly illusion but lost control is also what makes us move!

The following four chapters (6 – 9) describe and review specific methods that have been developed and used in past projects. The task for the contributing partners was to describe their choice of evaluation methods that can be used in the design process for both ADAS and IVIS. Contributing partners were asked to use the following headings in their reviews:

- Project
- Purpose of method
- Description of method
- Specific Human Centred Design components
- Towards a Human Centred Design method

Both quantitative and qualitative methods have been described. There is no contradiction between quantitative and qualitative methods but they are complementary tools that can give answers to quite different questions.

The group from Austria (chapter 6) predominantly focused on qualitative methods: observations, focus groups, checklists, expert evaluation and interviews. Their point of departure is social sciences were all of these methods are commonly used. Ample information of the methods is given in the chapter. The methods/tools have been developed in several past projects and references are given to these. All the methods reviewed in this chapter include the use of human subjects (users). Thus, they fit very well into a HCD approach. Figure 7 makes a distinction between product planning, development, evaluation and implementation and the qualitative methods proposed fit very well into all of four aspects but at different stages of the process. The relationship between the different methods and how they complement each other are also discussed. They specifically point to the idea to use qualitative tools as a preparation for later quantitative methods. Interviews, focus group etc can be used to make up an inventory of possible items which can be investigated with the help of quantitative methods and questionnaires, design of user experiments etc. Qualitative tools can be an excellent probe to collect very detailed information that is very difficult to capture with questionnaires and experiments. What is lacking according to the authors is an integration of methodologies and guidelines on their use.

The succeeding chapter (7) describes in short one specific method developed in the HASTE project. The primary aim of the method was to investigate safety impacts (effects of distraction) of IVIS but it is also considered applicable to ADAS type of systems. The intention was to develop a method that could be used in several phases of a design process. The method was developed during consecutive driving simulator experiments with both real and surrogate IVIS. Several driving behaviour metrics and subjective measures were used in the evaluation. The focus was to identify and discriminate between different types of workload (visual and cognitive) and to provide information that could be used for a redesign of a system. What was lacking was to further investigate how the method could be used in the evaluation of ADAS implementation and to identify possible positive effects of both IVIS and ADAS. Now only negative effects of IVIS could be identified.

The Occlusion Method described in chapter 8 have been used in several projects and emanate from work performed by Godthelp and colleagues (Godthelp et al., 1984) when developing the TLC (Time to Line Crossing) measure back in the 80ties. In the context described here the Occlusion Method is proposed to be used in the evaluation of IVIS effects on driving performance. A kind of reversed approach is used here as an IVIS task performance is measured while being interrupted by the primary driving task. The idea is to see how the IVIS task can be interrupted and resumed (chopped up into to smaller pieces) without affecting the driving task performance. The method is aimed at an early stage of the design process to investigate the design "space" for the interaction between the drivers an IVIS using prototype versions of the intended system.

The final review is more focused on the design of ADAS type of implementations. The method reviewed was developed in the ADVISORS project. Different actors (e.g. end-users, manufacturers, and authorities) are identified, all having different motives and restrictions for their decisions and actions e.g. willingness to pay, possibilities to manufacture and marketing, legislation, social welfare etc. The method aims at capturing different actor's opinions and attitudes to ADAS by using of interviews. Furthermore a prospective aspect is included as the respondents are asked to look in the crystal ball while giving their answers. This phase is followed by a conjoint analysis which aims at understanding the respondents' conception of utility. Several different ADAS functions have been investigated with this method and it is proposed that the results from such an investigation of acceptance and opinions can be used as input for the specification of requirements for various ADAS functions/implementations.

As pointed out in the introduction, this deliverable should be viewed as a living document which will be revised within the further work in TFC. There will be a final version of the draft identified as C/. The notes made here in the discussion should be considered in the further work on how to fruitfully apply HCD in the area of advanced driver support systems like ADAS and IVIS.

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11. CONCLUSIONS AND RECOMMENDATIONS

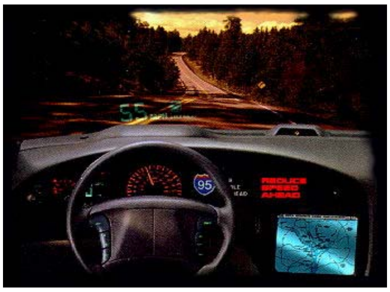
The conclusions and recommendations which can be drawn from what has been presented and discussed in this deliverable are as follows:

- A theoretical framework or theory of the problem at hand can contribute in several ways when designing IVIS and ADAS e.g. problem definition and understanding, proposal of actions to resolve problems, and evaluation of implementation of problem solution
- However, we are still waiting for the big shining star theory/model to appear on the stage which will help us understand both the all embracing big view down to the tiny facets of driver behaviour – but we can do quite a lot with what we have so far!
- The principles of Human Centred Design and the active involvement of end-users in the process from the initial idea to the final product can be far more utilised in order to promote safety and usability (appearance should not be forgotten!)
- The iterative process specification of design, implementation (mock-up, simulation, prototyping, product) and evaluation with users should be utilised as the core of a successful design.
- Standards and guidelines as the ESoP can be a very useful tool for the development of both IVIS and ADAS. There is however a need for further development specifically in view of ADAS. The pros and cons of ESoP should be further investigated and the search for truth should not always be taken as an excuse for not standardising.
- Both quantitative (e.g. interviews) and qualitative methods (e.g. experiments) should be used for evaluation in the design process. These methods are complementary and not competitive. They can answer different questions.
- There seem to be more methods available for the evaluation of IVIS and specifically for detailed investigations of different aspects of the interaction between the driver and the system (e.g. level of workload, different types of workload, glance time and interference.) The focus has been on the search for potential adverse effects and not so much on the positive effects. Thus, it is recommended to develop methods that aim at identifying positive effects form both ADAS and IVIS.
- Furthermore, we need to improve our tools to investigate the more “tight” communication between a driver and ADAS. For instance how do we get the drive in the out of control loop without jeopardizing safety?
- Finally, we need to consider the broader context in which ADAS and IVIS are developed what are the objectives of different stakeholders and their view of the future.
- The next and final version of this deliverable should further explore the HCD approach in view of advanced driver support systems like ADAS and IVIS.

Deliverable C.7

Annex 2

SafeTE
Safety Testing and Evaluation



Johan Engström, VTEC & Selina Mårdh, VTI
Borlänge, 2006-12-19

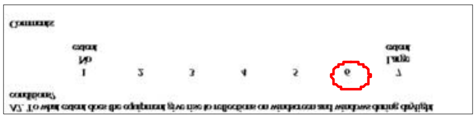
Objectives

- Development **and detailed specification** of a safety assessment methodology for **IVIS** (In-vehicle Information Systems)
- Intended mainly for (summative) evaluation of **systems already on the market** -> consumer information purposes
- Should provide an **valid, objective and repeatable** safety assessment

Measurements

1. Subjective assessment

Expert checklist



2. Objective assessment

Visual demand

Eye movements

Cognitive demand

Visual Detection Task (VDT)

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Assessment components of the SafeTE methodology

- Checklist
  - subjective expert evaluation (system level)
- Visual demand assessment
  - the degree to which the driver has to redirect gaze away from the forward roadway in order to perform a task (function level)
- Cognitive demand assessment
  - the amount of cognitive resources needed to perform a task (function level) incoming

The SafeTE specification is the detailed recipe on how to perform the evaluation using the assessments included

The final output is a three dimensional ”Star rating”

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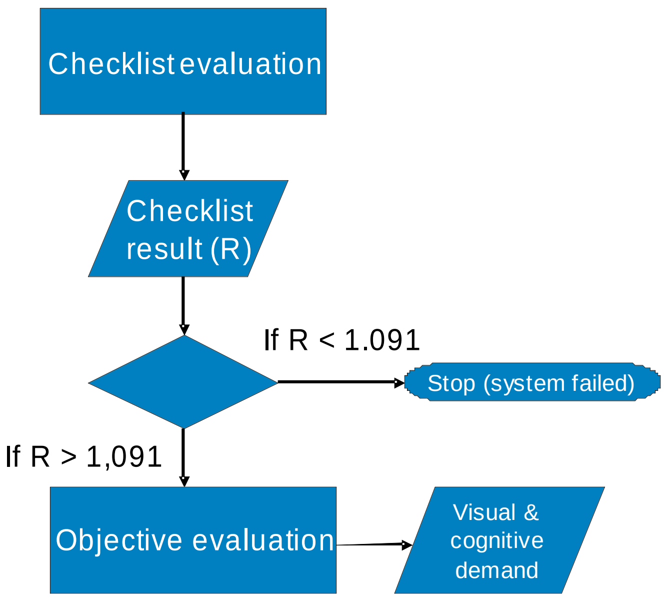
Checklist sections

- Mental workload
- System interaction
- Visual information
- Effects on driver behaviour
- Placement of system components
- Auditory information
- Possible driver support

Selina Mårdh

General procedure



SafeTE

Variables that are specified by the methodology

- Recruitment of experts for the checklist
- Recruitment of subjects
- Choice of evaluation scenario
- Selection of tasks
- Instructions
- Familiarisation and training
- Field test
- Analysis procedure

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SafeTE

Main achievements

- First version of a detailed procedure for IVIS safety evaluation that:
  - Is scientifically based
  - Is diagnostic of the type of demand imposed to the system (visual/cognitive)
  - Provides a 3-dimensional rating with a (relatively) straightforward interpretation
  - ”Clean” measures of visual and cognitive demand -> easier to relate to accident data
- Many new ideas
- The SafeTE methodology is the first of its kind!

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