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Development of an Integrated HMI-concept for Active Safety Systems

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ABSTRACT

Today, in the 21st century, progressively more, computing and communication-based technologies are being implemented in cars and the complexity of the driver-vehicle interface increases. The consumers are more sophisticated and expecting more content in their car with higher levels of quality. They demand features that are smarter, better crafted and easier to use. They expect their vehicle to be safe. To increase safety vehicles today will take action to prevent accidents, instead of making the consequences of a possible accident as small as possible.

Safety is the guiding principle for Volvo Car Corporation, preventing accidents; through active safety systems are among other, important research areas today. The numbers of such systems will most likely increase radically over the coming years as they are seen as very important to stay competitive. So far every system has been developed as stand alone functions, which if this continues, will lead to unnecessarily complex driver environments. The problem addressed in this thesis, is therefore how to find a holistic Human Machine Interface (HMI), which gives the driver a clear overview and good understanding of the active safety systems. To satisfy more demanding customers, system personalization also needs to be considered as well as its interactivity and flexibility.

To meet these goals and to be able to from a user-centered approach develop a design solution we had to through literature study find out; which theories to use to be able to understand driver behaviour and how that influences safety in driving, and what influences the driver in the context of driving. Further we needed to find out which demands there are for HMI in cars, to be able to design for safe interaction and usability. To understand driver behaviours and their relation to in-vehicle systems, we carried out semi structured interviews and questionnaires. The results concerning the drivers' relation to in-vehicle systems show that most of the drivers do not personally adjust the systems in the car, more than very occasionally, at the same time the majority would like the opportunity to do so for the feeling of control.

The result we gained from the study were interpreted and specified into user requirements. These requirements together with our literature background and a competitor analysis were the base to development of two simple prototypes. These prototypes were evaluated with the users, to ensure that the requirements in the context of driving were fulfilled. The results from the evaluation were used to further evolve our design into a final interactive design solution.

The conclusions of our study is summarized in statements describing how an integrated and flexible HMI, for active safety systems, together with an intuitive interaction could be designed to meet the consumers and the markets increasing demands of today.

Keywords: Active safety, Human Machine Interface (HMI), User-Centered Design (UCD).

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1 INTRODUCTION

Today, consumers are more sophisticated than in the past, expecting more content in their vehicle with higher levels of quality and design. They are demanding features that are smarter, better crafted and easier to use. Due to the customers' demands automakers are increasingly focusing on design, interior content and layout in this competitive industry. Quality is now an aspect the consumers expect when they purchase a vehicle, as their expectation that a vehicle will be safe.

Successful products and services therefore need to be evolving; they must provide an emotional connection, they need to have some level of personalization and they will have to be more interactive and flexible to enable the consumer to do things they could not do in the past. It's the end consumer that is important because they are the only ones at the end who are injecting money into the industry and deciding if a certain idea, concept or product will be successful. (Gehm, 2005)

1.1 BACKGROUND

The competition on the Swedish car market is today fully globalized and the complexity of the products arises quickly. This forces the companies to increase the internal and external efficiency and to adjust their products to new customer needs and new contexts of use. The challenge today is to find the product characteristics that contribute most to increased customer satisfaction.

According to Gustavsson (1998) the development of any new product is about identifying the customer needs for the product and realizing the products in a suitable way.

To develop the next generation of safety systems, it is important to focus on combining related technologies to provide more benefits. The product developers need to look at the totality of driving, according to Costlow (2006). The developers are extending the capabilities of existing products to make simple products into more complex systems that offer features that take stress away from drivers and at the same time minimizing the risk of accidents.

Gehm (2005) state, that to be able to increase the drivers' and the passengers' safety, vehicles will now be taking action to prevent diverse accidents (through active safety systems), instead of making the consequences of a possible accident as small as possible (through passive safety systems).

1.1.1 Advanced Driver Assistance Systems

Advanced Driver Assistance Systems (ADAS) are systems with the purpose to increase safety and/or comfort, to help the driver focus on the driving. These systems can for example be adaptive safe following and collision warning. (Engström et al., n.d.[1])

There are three issues concerning Human-Machine Interaction (HMI) design for these ADAS, considering; how to assure that the driver makes the correct response to the specific system warning, how to understand the behavioural adaptation effects there might be when ADAS is implemented, and how to get user acceptance for these systems.

[1] n.d. = no date

1.2 PROBLEM AND GOAL

Now in the 21st century, progressively more, computing and communications-based technologies are being implemented in cars and the complexity of the driver-vehicle interface increases.

Because of this there is a danger that drivers in the future will be overwhelmed by all the functionality in their vehicles. The effect might hopefully be that drivers choose not to use particular systems. Or in the worst case, the demands of interacting with numerous systems may affect the drivers' capacity to control their vehicles in a safe manner. Different types of distraction and lack of attention on the road causes many road accidents today, so systems, which may contribute to this problem, must be carefully designed. (Burnett and Porter, 2001)

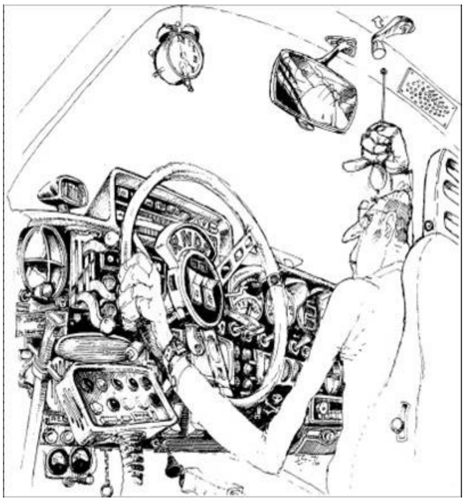

Figure 1: Illustration of a complex driver environment (Davidsson and Moric, 2005)

Safety is the guiding principle for Volvo Car Corporation (VCC), preventing accidents, through active safety systems are among other, important research areas today. The numbers of active safety systems in a vehicle will most likely increase radically over the coming years, since implementation of such systems is seen as very important to stay competitive. So far every system has been developed as stand alone functions, which if this continues, will lead to unnecessarily complex driver environments (see figure 1). The problem addressed in this thesis, is therefore how to find a holistic Human Machine Interface (HMI) which gives the driver a clear overview and good understanding of the active safety systems. To satisfy more demanding customers, system personalization also needs to be considered as well as its interactivity and flexibility.

Our questions at issue are:

- How can we create a HMI solution to make the driver more aware of the car's active safety systems?
- How can the driver, in an intuitive way interact with the HMI solution and make personal adjustments to the car's active safety systems?
- How can we design a flexible HMI solution that achieves the scalability demands (i.e. to make the solution suited for different car models and varied numbers of active safety systems implemented)?

1.2.1 Design concept

The answers to the questions above will be used to create two concepts for an integrated HMI solution for active safety systems. The concept will involve two different driver types, based on their willingness to personally adjust the systems: *low willingness*, meaning that the driver is not that willing to adjust the systems, and *middle willingness*, meaning that the driver is willing to adjust the systems to him/her personally.

The concept will also see to the environmental issues by defining two different driving environments: *inner-city driving*; which often means oncoming traffic, short distances, crossings and traffic lights, line changes and low speed, and large quantity of information, and *motorway driving*; which often means high speed, no oncoming traffic, over takings, long distances and monotonous driving.

The concept design should deal with the near future, about five years into the future (around year 2011), and be prototyped in two stages, one Lo-Fi prototype (paper) and one interactive Hi-Fi prototype (in Macromedia Flash).

1.3 LIMITATIONS

This thesis is limited to investigate how the driver interacts with the car and not how the car interacts with the driver (e.g. warnings). Cultural differences are not taken into account.

1.4 TARGETED READERS

The primary target group of readers is people inside VCC working with research and development in the area of interaction design, active safety and HMI solutions. The secondary target group of readers might be people doing research work on vehicle design and other M.Sc students in interaction design.

2 THEORY

The driving task, is a complex every day task, that provides focus for a wide range of theories and methodologies. Research on drivers and the driving task covers a broad range of topics within psychology, for example by providing a theoretical basis for *understanding road users' behaviour*, which is one of our areas of interest together with theories concerning *how driver behaviour influences the safety in driving*. To take the drivers' capabilities into account as well as individual and momentary differences in these capabilities may be one of the most challenging tasks for traffic psychology, according Groeger and Rothengatter (1998).

Groeger and Rothengatter (1998) further state that design that is adapted to the drivers' capabilities and limitations enhances safety. The key to design for drivers and road environment is according to Groeger and Rothengatter (1998), the understanding of how drivers perceive their environment and how they process the information from the environment. *Designing for safety* is another important area of interest, concerning the demands for HMI in cars taking driver workload and distraction into account. To be able to, at the same time, *design for usability and pleasure* different design dimensions need to be concerned as well.

2.1 THE CONCEPT OF CONTROL

Driving can be seen as a controlled process where the individual, the vehicle and the environment interacts. Driving behaviour can be described as ways to achieve a series of different goals. Control theory is a framework to represent goal directed processes with human and machine. (Ström et al., 2005)

Hollnagel et al. (2003) state that driving is a dynamic activity and a model of driving should meet two criteria; allow control to exist on several levels simultaneously, and describe the driver and the car as a joint system, rather than two separate systems, Joint Driver-Vehicle System (JDVS). The first criteria reflect that both humans and machines pursue several goals at the same time. The second criteria deals with the connections and dependencies between the systems that take control of the car and those who runs in the background, determine how easy it is to control the car and how well the JDVS performs.

Hollnagel et al. (2003) explains that the driving act can be divided into four different loops, each loop represents different levels of control, in the Driver-in-Control (DiC) model (see figure 2). The DiC model gives a summarized picture of the drivers working processes during driving in the four different levels of control, which are; *tracking*, *regulation*, *monitoring* and *targeting*.

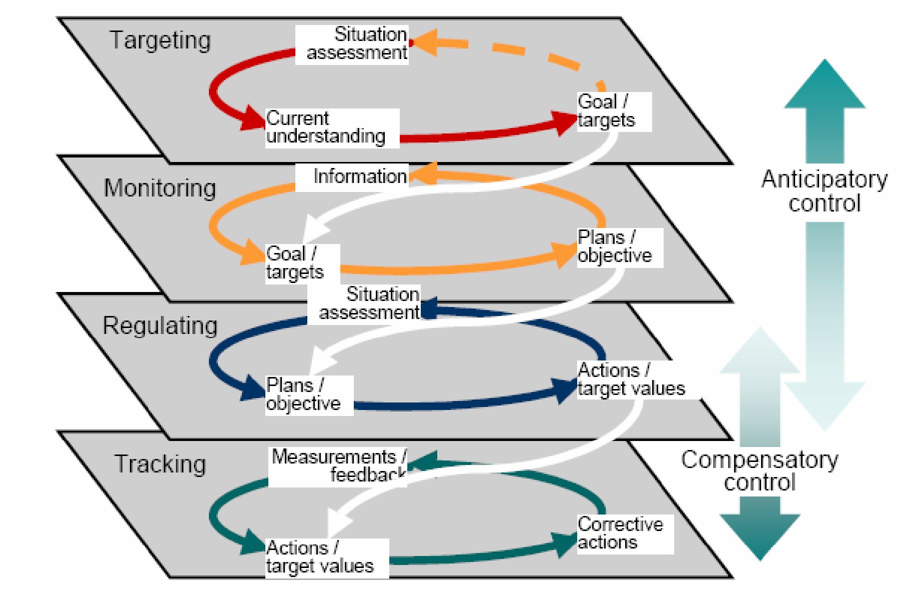

Figure 2: The Driver in Control (DiC) model (Hollnagel et al., 2003)

The tracking level concerns activities such as keeping speed and distance to other cars on the road. *The regulation level* supplies the tracking level with goals and criteria; this could be a new speed or a different placement on the road. *The monitoring level* includes the status of the vehicle in condition to the traffic environment. Dangerous situations or changes in the traffic environment are discovered in this level and actions are sent down to the underlying levels so changes can be done. *The targeting level* decides criteria for the destination and driving and changes in these criteria's.

The coupling between the four loops illustrates how they are functionally connected. The levels are generally linked by goals or objectives (higher levels set target values for lower levels) and feedback (from lower to higher levels). The DiC model describes how disturbances can propagate between control levels. A change in goals on the targeting level, such as an altered destination or a new arrival time, will affect plans and actions possibly leading to, for example, more risky maneuvers. Similarly, a disturbance at the tracking level, will affect regulating, and a large disturbance may even affect monitoring.

Effective control means that the JDVS must be in control on all levels at the same time. Ineffective control happens when control is lost of one or more of the loops. (Hollnagel et al., 2003)

2.1.1 Distraction

"Distraction occurs when a driver is delayed in the recognition of information needed to safely accomplish the driving task because some event, activity, object, or person within or outside the vehicle compels or induces the drivers' shifting attention away from the driving task."

(eSafetysupport, (2006) p. 282)

Even though the driving task (the primary task) is complex, it is usual for drivers to engage in various other activities while driving, so called secondary tasks. Any activity that distracts the driver or competes for the attention while driving has the potential to degrade driving performance and have serious consequences for road safety, according to Young et al. (2003).

The effect in traffic safety of the use of electronic devices, many of which are not essential to the driving task, has received significant attention in recent years. According to Dewar (2001) it appears that modern motor vehicles are gradually becoming mobile offices, as drivers feel the need to be in touch with colleagues, clients, friends and family and to search the internet and to be entertained with the latest technology. Drivers are starting to want such devices, and this trend is likely to continue. The problem is the tendency for the drivers' attention to be taken by use of the device rather than the primary task – driving, according to Dewar (2001).

Four different kinds of distractions are mentioned by the National Highway Traffic Safety Administration (NHTSA); *visual*, *auditory*, *biomechanical* and *cognitive*. For example, operating a particular device, such as a mobile phone, may involve all four forms of distraction: *biomechanical* distraction caused by dialing a phone number or pressing buttons to receive a call; *visual* distraction caused by looking at the phone to dial a number or receive a call; *auditory* distraction caused by holding a conversation with a person; and *cognitive* distraction caused by focusing on the topic of conversation rather than monitoring any hazards or changes in the road environment. (Young, et al. 2003)

The visual component of such in-vehicle tasks can take the drivers eyes off the road for several seconds. Even when the eyes are on the road, if a driver is occupied with something like a phone conversation, the ability to respond to new information is significantly reduced. The potential for driver distraction when using these devices is evident, according to Dewar (2001). Dewar (2001) further state that to the extend that the drivers mind is off the road there is potential for an accident. There is concern about driver workload – both visual and cognitive and in particular the distraction created by use of electronic devices.

2.1.2 Workload

In recent years the driving task has come to require more mental skills (such as: visual attention, decision making, risk perception etc.) because the number of complexity of controls and instrument panel displays have increased and road geometry, traffic control devices, traffic volume, etc. present greater challenges than in the past. Dewar (2001) state that the demands of the driving task also have changed in recent decades as some vehicle features have become automated or power assisted.

A series of technological change can create burdens and complexities for the human, according to Woods (1993). Today we will have to increase our ability to digest and interpret data; we will also be able to focus on the critically relevant data since massive amounts of data are available to us. According to Dewar et al. (2001) driver error associates with failure to detect, understand or respond to information which frequently contributes to roadway collisions.

In many cars it can be problematic to find the required control quickly, carry out the appropriate operation and be sure that the correct action has been made, according to Burnett and Porter (2001). Dewar (2001) state that vehicle design affects driver workload, and if the design is not based on human factors principles, both mental and physical workload can increase, which in turn can increase drivers stress and fatigue and the likelihood of an accident.

De Waard (1996) state that the future cars will be filled with high technology in-vehicle devices which will increase driver mental workload and possibly affect behaviour negatively, and will therefore be a threat to traffic safety.

OVERLOAD VS. UNDERLOAD

The driving task to be selected at any given instant is presumed to be based on a number of factors, including the perceived criticality to safety, the times to complete the various competing tasks, the driver preferences and so on, according to Green (1994).

The extent to which a task interferes with driving depends primarily on the extent to which it is visual, because driving is primarily a visual task. An in-vehicle demand doesn't necessarily mean it will interfere with driving, but the addition of a task may load some drivers to the limit, leading to a degradation of driver performance, according to Green (1994). When competing tasks cause an unacceptable degradation the driver is considered "overloaded", according to Green (1994). Whether or not task overload occurs depends on the number of tasks competing for attention and the nature of these tasks.

According to Green (1994) safety and ease of use are connected. De Waard (1996) further states that the new car in-vehicle systems may also have the opposite effect of driver workload (e.g. underload). Dewar (2001) state that as the workload increases in complex systems, designers has introduced automation to reduce the load and to enhance traffic safety. These devices include systems that directly affect the driving task, and are considered to offer the following benefits; reduce crashes resulting from driver error, reduce congestion and delay, increase driver comfort, increase driver attention and increase mobility for all drivers.

With increased automation comes a shift in the drivers' role from operational to supervisory. According to Dewar (2001), humans operate best at optimal level of arousal, either too much workload or too little workload. If vehicle operation becomes too automated drivers will reduce attention and gradually lose the ability to control the vehicle when it comes to an emergency in which they must take over control, therefore the possibility of behavioural compensation when using in-vehicle controls must be considered. According to Dewar (2001) it is evident that much more knowledge about the safety effects of Intelligent Transportation Systems (ITS) and vehicle automation is needed, especially from the point of driver behaviour and reaction.

2.2 INDIVIDUAL DIFFERENCES

Road users vary greatly along a number of psychological dimensions; personality, emotion, motivation and social behaviour. These factors as they relate to driving often become intertwined and impossible to separate according to Dewar (2001). For example, personality is based in part on each individual's unique experiences and is reflected in his or her emotions, motives and social behaviour in everyday life, as well as on the road.

Personalities can appear in many different manners. The Big Five is a model (see table 1) for discerning personalities which consists of five personality dimensions, that most of the individual differences in human personality can be classified into. The dimensions of the Big Five are; (OCEAN) Openness (O), Conscientiousness (C), Extraversion (E), Agreeableness (A), Neuroticism (N). (Gosling, Rentfrow and Swann, 2003)

Characteristics of the high scorer	Scales GLOBAL DOMAINS	Characteristics of the low scorer
Curious, broad interests, creative, original, imaginative, untraditional, exlopre the unfamiliar.	**Openness (O)** Assesses proactive seeking and appreciation of experience for its own sake; toleration for and exploration of the unfamiliar.	Conventional, down-to-earth, narrow interests, unartistic, unanalytical.
Organized, reliable, hard-working, self-disciplined, punctual, scrupulous, neat, ambitious, persevering.	**Conscientiousness (C)** Assesses the individual's degree of organization, persistence, and motivation in goal-directed behaviour. Contrasts dependable, fastidious people with those who are lackadaisical and sloppy.	Aimless, unreliable, lazy, careless, lax, negligent, weak-willed, hedonistic.
Sociable, active, talkative, person-oriented, optimistic, need for stimulation, active, fun-loving, affectionate.	**Extraversion (E)** Assesses quantity and intensity of interpersonal interaction; activity level; need for stimulation; and capacity for joy.	Reserved, sober, unexuberant, aloof, task-orientes, retiring, quiet.
Soft-hearted, good-natures, trusting, helpful, forgiving, gullible, straightforward.	**Agreeableness (A)** Assesses the quality of one's interpersonal orientation along a continuum from compassion to antagonism in thoughts, feelings, and actions.	Cynical, rude, suspicious, uncooperative, vengeful, ruthless, irritable, manipulative.
Worrying, nervous, emotional, insecure, inadequate, hypochondriacal.	**Neuroticism (N)** Assesses adjustment versus emotional instability. Identifies individuals prone to psychological distress, unrealistic ideas, excessive cravings or urges, and maladaptive coping responses.	Calm, relaxed, unemotional, hardy, secure, self-satisfied.

Table 1: The Big Five personality factors (Costa and McCrae (1992) see Ström et al., 2005)

Personalities vary in traffic situations in terms of driving skills, attitudes and behaviour on the road. Emotional impairment, stress, sex, physical limitations and certain social and lifestyle characteristics can play a role when it comes to traffic safety, according to Dewar (2001).

Dewar (2001) state that the research on sex differences suggests that females are more cautious drivers, have less driving experience and drive more in daylight and on short trips, as compared to men. Men drive greater distances, more often at hazardous times and in hazardous conditions, and generally take more risks on the road, use seatbelts less often, and are more likely to drive intoxicated.

2.2.1 Risk propensity

A central concept in driver motivation is risk taking. According to Svensson (1981) one of the most common and best known risky activities in modern society is that of driving a car. Someone's willingness to take risks depends on different factors, as personality and demographic variables, according to Nicholson et al. (2005) see Ström et al. (2005). An extraverted person, especially sensation seeking and openness are individual characteristics that have been studied as it relates to risk taking. According to Dewar (2001) sensation seeking is the need for varied, novel and complex experiences and sensations, and the willingness to take risks in order to achieve these experiences. Drivers scoring high on sensation seeking drive at greater highway speeds, overtake more, change lanes more, have more driving violations, and report less seat belt use than others, according to Dewar (2001).

Sensation seeking is found by Arnett (1994) to be related to aggressiveness, at least among adolescents, and it is likely that it is related to other personality traits as well. In particular, it is likely to be related to characteristics such as extraversion, psychoticism and impulsivity. Males are found to be higher in sensation seeking than females, among adolescents and adults. Age differences are also found in the AISS, in general where adolescents reporting higher levels of sensation seeking than adults.

Persons that feel in control over a situation are more likely to take risks according to McCrimmon and Wehrung (1986) see Ström et al. (2005). It has repeatedly been reported that drivers overestimate their own driving skills. Svensson (1981) has found results that illustrate a strong tendency among drivers to believe themselves to be more skillful and less risky than other drivers (i.e. high illusion of control). When people consider themselves to be better than others an overestimation of the degree of control drivers has over events and their outcomes may be inferred. This may indicate that drivers believe that traffic rules are more appropriate to the other worse driver than to themselves. The illusion of control and the overestimation of the degree of control increases with driving experience, according to Rothengatter (2002).

According to Dewar (2001) there are two major types of mechanisms that determine how drivers adjust to perceived risk; high-level decision making, as avoiding night driving, choice of vehicle and motives for driving, and low-level control factors, which relate to on-road driving activity such as lane keeping and speed choice. According to Alhakami and Slovic (1994) see Ström et al. (2005) there is a relation between perceived risk and perceived benefit, which is linked to positive/negative influence associated with an activity. People do not only judge an activity or a technique on the basis of what they think about it, but also what they feel about it. If the person likes the activity he/she values the risk as low and the benefit as high.

It is difficult to categories people as risk taking or not, though some are risk taking in some situations and not in other situations. According to Weber, Blais and Betz (2002), risk propensity is highly domain-specific and depends on each situation.

2.2.2 Emotions and mood

According to Dewar (2001) high risk drivers have been found to be emotionally unstable, hostile, and resistant toward authority, tense, emotionally immature and anxious. The psychological well-being of drivers is influenced by many factors in the transportation system, including roadway design, traffic conditions, vehicle conditions and weather, according to Dewar (2001).

Feelings that play a big role in traffic are boredom, pleasure of fast driving, relief and feelings about skill. Many of these feelings are related to safe or unsafe behaviour. (Levelt, 2003 see Ström et al., 2005)

Most emotions arise when we translate our motives and concerns into goal-directed actions and they have a function within the individual-environment interaction. According to Ekman and Davidson (1994) a requirement for emotion is that a situation is perceived as *positive* or *negative* for one's concern. *Positive emotions* are elicited by events that satisfy some motive, that increase one's power of survival, or express the successful exercise of one's capabilities. Positive emotions tend to result from achieving conditions of satisfaction. Joy is the signal that is dependent on the various incidents; goal achievement, increased trust in obtaining satisfaction and actual satisfaction. Many *negative emotions* result from painful sensations and form threat and harm to some concern. The negative emotions alert that some action should be undertaken to set things right or prevent unpleasant things from happening. (Ekman and Davidson, 1994)

According to Dewar (2001) strong negative emotions can clearly influence driving. In a study by Lewelt (2003) see Ström et al. (2005) the most frequently reported emotions was pleasure (more than half of all emotions) and anger (nearly a quarter of all emotions), and this study shows that in fact the positive emotions occur more frequently than negative emotions. According to Rothban (n.d.) The Big Five factors shows overlapping with extraversion and positive emotionality, neuroticism with negative emotionality and conscientiousness with constraint.

2.2.3 Trust

Muir (1994) state that trust always belongs to a specific person or object. Trust is often described as the person's expectations of another. The concept of trust is also directed towards the future and the person's talent to predict future satisfactions, behaviours or events.

Trust is an important factor if an automated system should be used or not according to Muir and Moray (1996). Systems are often highly trusted in the beginning of use, because the user trusts the system to work properly. Trust is dynamic and the users' trust in the system might change during experience and when the systems performance drops under a certain point the user will override the system and do the task manually.

Trust in machines according to Rudin-Brown and Noy (n.d.) have to do with the technical competence of the machine, since the machine is built to do a specific task and users expect it do to its job properly. Although the quality of the automation might vary between systems but also different functions in that machine so it is important that the user do not trust all the functions the same.

Muir and Moray (1996) gives a summary of how trust can be defined and measured. Trust = *Predictability* + *Dependability* + *Faith* + *Competence* + *Responsibility* + *Reliability.* According to Muir (1994), the beginning and overall trust of a relationship is based upon predictability and the predictability depends on how constrained the system is. A more constrained is more predictable. The relationship is evolving and the dependability becomes more important. The past predictability and dependability is the base for us to see into the future and asses information about the other person's motive for being in the relationship, this is what Muir (1994) calls faith. Competence dominates our trust when it comes to machines, according to Muir (1994). When the competence is not there the responsibility will be the base. Reliability is how the functions respond or act to similar situations at different times, according to Muir and Moray (1996).

ADAPTATION

In some extent trust might be a problem, if the user trusts the system to much, he or she might not take over the system when it is necessary (Muir (1994) and Rudin-Brown and Noy (n.d.)). This phenomenon is often called behavioural adaptation, which is only one outcome that might lead to dangerous situations, and is an important factor to take into account when designing and implementing new safety technologies, according to Rudin-Brown and Noy (n.d.).

Behavioural adaptation might depend on the drivers' *locus of control*; this is anyhow the statement of Montag and Comrey (1987). If the driver has an *internal locus of control* he or she is more likely to relay on his or her own skills and abilities and will have a more direct involvement with the driving task. A driver that has an *external locus of control* is more likely to trust the system to do its job and is more willingly to give up the control. According to Montag and Comrey (1987) people with external locus of control might easier over rely on a device.

2.3 DESIGNING FOR SAFETY

"Cars are driven by people. The guiding principle behind every thing we make at Volvo, therefore, is – and must remain – safety."
(Volvo Car Corporation)

When a new item or system is integrated into a vehicle it will often change the relationship between the driver, the vehicle, other road users and the road environment. The new item or system will also affect the safety whether the item or system is design to. The affects can, according to Stevens (2000), be divided into three groups: *system safety* which focuses on design faults or system malfunctions that could lead to an accident, *Human-Machine Interaction (HMI) safety* which concerns the interaction of the driver with a new system that through lack of understanding, by increasing stress or by diverting attention from the task of vehicle control, cause an accident, and *traffic safety* which concerns the effect of a new system on all other aspects of the traffic environment.

2.3.1 Human-Machine Interaction safety

According to Rogers et al. (2000), a well designed Human-Computer Interface (HCI) is very essential in vehicle interior, since the user only can spare short burst of attention to be able to operate the vehicle in a safe manner. Interface design for in-car systems is clearly becoming more difficult as more information sources are made available to the driver.

User interfaces in the car must serve the users' needs and not cause unnecessary safety risks. Since it is impossible to guarantee a completely safe interface, interface designers must, according Rogers et al. (2000), work toward at least not worsening the safety situation, and leave the task of improving vehicle safety to others. It is the responsibility of the driver to judge his own level of safe attention to the primary task – to control the vehicle, according to Rogers et al. (2000).

It is the interface designer's responsibility to provide interfaces that are safe, easy to use and with heavy reliance on personality, according to Rogers et al. (2000). The key elements to create usable interfaces to meet the demands in the vehicle environment is to make the interfaces adaptive, since they give the driver quicker access to the information he needs or wants, in an appropriate form, Rogers et al. (2000) state.

CHALLENGES FOR VOLVO IN DESIGNING AN ADVANCED HMI

A future Volvo HMI should, according to Davidsson and Moric (2005) be designed; to contribute to less visual and mental workload, to have good priority among functions (e.g. frequent functions with discrete controls), to be easy to use (e.g. know the present location in menus, have clear exits), with a thorough menu structure, to have the functions legally and safely available while driving, and get better rating in e.g. Euro NCAP than the competitors. The goal is to; *have eyes on road*, *hands on wheel* and *mind on traffic*.

"Low distraction in cars contributes to active safety", and active safety systems need to be designed to; give a safety net effect, not annoy driver (so that it will be turned off) and not give an increased risk behaviour.

SAFE IN-VEHICLE DESIGN

An increasing amount of information for the driver is being placed inside vehicles, especially as technology advances and intelligent transportation systems become implemented. Dewar (2001) state that the introduction of more information systems into vehicles poses a special problem for drivers who are more prone to distraction, reduced attention, confusion and information overload than others.

In the modern car one can find a great number of both electrical and mechanical controls for a variety of functions designed and placed in various ways. Some of these are unfamiliar to drivers and seldom used. Dewar (2001) mean that confusion often arises among drivers of unfamiliar vehicles (e.g. rental vehicles), and therefore unfamiliar vehicles appear to be less safe than familiar ones.

Dewar (2001) presents some guidelines for safe in-vehicle design;

- *The placement of displays* should be such as to allow them to be easily seen by all drivers. They should not be hidden by the steering wheel or stalks. It is preferable to locate complex displays high on the instrument panel in order to minimize the amount of time a drivers eyes must be off the road to read the display. Visual clutter within the vehicle increases the number of glances made by drivers, suggesting that panels should be designed with displays that are easy to see and unnecessary information should be avoided.
- *The placement of controls* should, as well as the placement of displays, be easily seen and reached. There are three main features of vehicle controls; *type*, *location* and *operation*. The coding (e.g. color, shape and consistent placement) of the control, can assist the driver in identifying and using controls.

> The expectancies that the drivers have for the placement and operation of vehicle controls are an important factor in their ability to use them efficiently. The perceived function influences how the control will be expected to operate, therefore one important consideration is control-display compatibility. That is, the control movement should correspond to its display.

With the variety of vehicle controls found in the various models of many manufacturers, there is a need to design with these expectations in mind by standardizing both their location and design. Designing controls and displays according to the users' expectancies will reduce the need for decoding and mental processing will reduce errors and time to learn how to use them and will increase speed of control use and information gaining from displays. When things are not located or do not operate as expected driver workload and perception-response time increase, according to Dewar (2001).

The design of controls for future cars will probably have greater embedded functionality, and a balance between single-function and multiple-function controls should, according to Burnett and Porter (2001), be sought out. It is far from clear what this balance might be, and whether novel control types (such as joysticks) may assist the driver.

Dewar (2001) state that, as technology advances more use will be made of the auditory mode – *voice controls and auditory displays*, some of which may relieve the visual sense of input to be processed. Automatic speech recognition (ASR) is today a reality within cars, which has clear benefits since it provides a "hands-free, eyes-free" way to interact, according to Burnett and Porter (2001). There are two recommendations considering the way to interact within the vehicle; ASR should only be used when operating a limited number of non-safety-related functions, and manual controls will always be necessary.

Burnett and Porter (2001) further state that driver-system interactions should make minimal use of the human visual sense, but Galitz (2002) state that graphical displays have numerous advantages; displayed objects are visible and provide a picture of the current context, which leads to that the user initiates actions and feels in control and thereby the user confidence increases. According to Galitz (2002) graphical systems are more entertaining, cleverer, more appealing and it aids learning.

Within the HCI field the interest to make use of *haptic* (tactile and kinaethetic) information is increasing. Burnett and Porter (2001) give three proposals why haptic information should be used within cars.

- Since the human body is capable of sensing a wide variety of haptic features, it enables traditional manual controls to provide extensive information concerning their function, mode of operation and current status, without using the visual system. (design in terms of size, shape, texture, orientation and tactile/force feedback)
- Older people with decreased visual and auditory capabilities will gain a lot from haptic information.
- The sense of touch can only be used in direct physical contact with an interface, which will lead to a natural emotional "closeness" with the interaction.

Burnett and Porter (2001) suggest that haptic interfaces within cars would lead to higher levels of user acceptability.

2.3.2 Interaction Design

"Good design is not only a matter of styling the surface. It is just as important to make the product easy to understand and use. If the product is not functional, it can't be beautiful."

(The Volvo Car Corporation Design Philosophy)

Interaction design, according to Preece et al. (2002), is about developing interactive products that are easy to learn, effective to use and provide an enjoyable user experience. According to Preece et al. (2002) it is now more understood by companies how customer satisfaction is greatly affected by the usability of products. As well as focusing on improving efficiency and productivity, interaction design is increasingly concerned with creating systems that are; satisfying, enjoyable, fun, entertaining, helpful, motivating, aesthetically pleasing, supportive of creativity, rewarding and emotionally fulfilling. (Preece et al., 2002)

MENTAL MODELS

Norman and Draper (1986) states that since people are different from computers, there are needs for mutual accommodation in the interaction between them. The computer can be thought of as a personal assistant, where the goals and intentions of the user becomes a primary concern. It can be viewed from the experience of the user, which considerably changes with the task, the person and the design of the system.

Norman (1986) state that people form internal mental models of themselves and of the things and people with whom they interact, which provide predictive and illustrative power for understanding the interaction. Mental models evolve naturally through interaction with the world and with the particular system and are highly affected by the nature of the interaction, coupled with the person's prior knowledge and understanding. According to Norman (1986) the models are neither complete nor accurate but they function to guide much human behaviour.

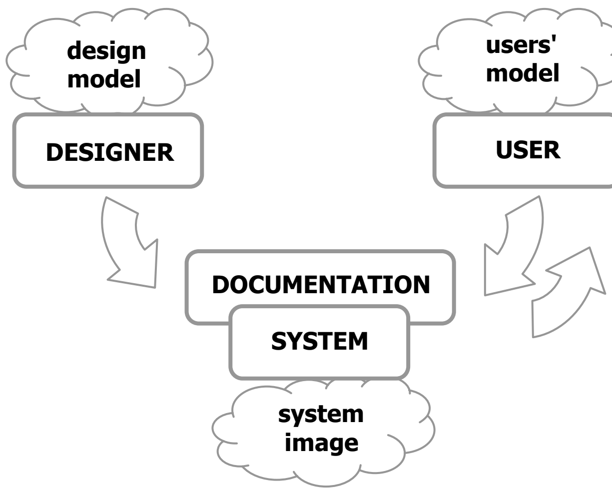

Figure 3: Mental models (Norman and Draper, 1986)

The *design model* is the conceptual model of the system to be built, which ideally is based on the users' task, requirements and capabilities. It will also have to consider the users' background, experience and the powers and limitations of the users' information processing mechanisms, most especially processing resources and short-term memory limits.

The user develops a mental model of the system, the *users' model*. It is not formed from the design model, it results from the way the user interpret the *system image*.

According to Norman (1986) the primary task of the designer is to construct an appropriate system image, realizing that everything the user interacts with helps to form that image, such as: the physical knobs, dials, keyboards, displays, documentation an instruction manuals, help facilities, text input and output as well as error massages. The designer should want the users' model to be compatible with the underlying conceptual model, the design model, which can only happen through interaction with the system image. *"If one hopes for the user to understand a system, to use it properly, and to enjoy using it, then it is up to the designer to make the system image explicit, intelligible and consistent"* (p.47), this goes for everything associated with the system.

Designing computer systems for people is especially difficult for a number of reasons. Any real system is the result of a series of tradeoffs that balance one design decision against another, that take time, effort and expense into account. The benefits of a design decision along one dimension almost always lead to defects along another dimension. The designer must consider the wide class of users, the physical limitations, the constraints caused by time and economics, and the limitation of technology. In all of this, the goal is user-centered design, which means providing intelligent, understandable tools that bridge the gap between people and systems: convivial tools. *"User-centered design emphasizes that the purpose of the system is to serve the user."*(p. 61)

USABILITY

“Attractive things work better.”

(Norman, 2004, p. 17)

According to Preece et al. (2002), usability goals are central to interaction design. A way of conceptualizing usability is in terms of design principles, which is indended to act like a set of reminders to designers. The best known design principles are concerned with how to determine what users should see and do when carrying out their task using an interactive product.

Norman (1988) writes about the six most common *design principles*, besides those, Nielsen (1993) present ten principles, *usability heuristics*, and Schneiderman and Pleisant (2005) define eight *golden rules* of interface design. They are applicable in most interactive systems, and must be interpreted, refined and extended for each environment. A few principles overlap each other and are therefore combined and presented as one below:

- *Visibility:* the more visible functions are the more likely users will be able to know what to do next. In contrast, when functions are out of sight, it makes them more difficult to find and know how to use. (Norman, 1988)
- *Feedback:* related to the concept of visibility is feedback. Feedback is about sending information about what action has been done and what has been accomplished, allowing the person to continue with the activity. The system should continuously inform the user about what it is doing and how it is interpreting the users' input. The system should also provide positive feedback, and it should provide partial feedback as information becomes available. Various kinds of feedback are available for interaction design – audio, tactile, verbal, visual, and combinations of these.

Using feedback in the right way can provide the necessary visibility for user interaction. (Norman, 1988, Nielsen, 1993 and Schneiderman and Pleisner, 2005)

- *Constraints:* the design concept of constraining refers to determining ways of restricting the kind of user interaction that can take place at a given moment. One advantage of constraining is that it prevents the users from selecting incorrect options and thereby reduces the chance of making a mistake. (Norman, 1988)
- *Mapping*: refers to the relationship between controls and their effects. Nearly all artefacts need some kind of mapping between controls and effects. (Norman, 1988)
- *Consistency*: refers to designing interfaces to have similar operations and use similar element for achieving similar tasks. One of the benefits of consistent interfaces is that they are easier to learn and use and the users will feel more confident in using the system. Therefore the same information should be presented in the same location on all screens and dialog boxes and it should be formatted in the same way to facilitate recognition, such as; identical terminology should be used in prompts, menus, and help messages; and consistent color, layout, capitalization, fonts, and so on should be employed throughout. (Norman, 1988, Nielsen, 1993 and Schneiderman and Pleisner, 2005)
- *Affordance*: is a term used to refer to an attribute of an object that allows people to know how to use it. At a very simple level, affordance means *"to provide a strong clue"*, (p.9) according to Norman (1988), who was responsible for originally promoting the concept. Norman (1999) state that when the affordance is the same as the intended use the object is easy to use. If the object transmits another action than the affordance does, it will probably lead to errors according to Gaver (1991).
- *Simple and natural dialogue*: user interfaces should be simplified as much as possible and should match the users' task in a natural way, such that the mapping between computer concepts and user concepts becomes as simple as possible. (Nielsen, 1993)
- *Speak the users' language:* as a part of User-Centered Design (UCD), the terminology in user interfaces should be based on the users' language and not on system oriented terms. (Nielsen, 1993)
- *Minimize user memory load:* computers should take over the burden of memory from the user as much as possible. People have a much easier time at recognizing something that is shown to them, than they have at recalling the same information from memory without help. (Nielsen, 1993 and Schneiderman and Pleisner, 2005)
- *Clearly Marked Exits:* users do not like to feel trapped by the computer. In order to increase the users' feelings of being in control of the dialogue, the system should offer the user an easy way out of as many situations as possible. (Nielsen, 1993)

- *Shortcuts:* it should both be possible to operate a user interface with the knowledge of just o few general rules, and it should also be possible for the experienced user to perform frequently used operations. (Nielsen, 1993)
- *Good error messages:* error messages should basically follow four simple rules; they should be phrased in clear language and avoid obscure codes, they should be precise rather than vague or general, they should constructively help the user to solve the problem, and they should be polite and not intimidate the user. (Nielsen, 1993)
- *Prevent errors:* even better than having the good error messages would be to avoid the error situation in the first place. Designing the system so that users cannot make serious errors. If a user makes an error, the interface should detect the error and offer simple, constructive, and specific instructions for recovery. (Nielsen, 1993 and Schneiderman and Pleisener, 2005)
- *Help and documentation:* even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the users' task, list concrete steps to be carried out, and not be too large. (Nielsen, 1993)
- *Cater to universal usability:* recognize the needs for diverse users and design for facilitating transformation of content. Novice-expert differences, agerange, disabilities, and technology diversity each enrich the spectrum or requirements that guide design. (Schneiderman and Pleisner, 2005)
- *Design dialogs to yield closure:* sequences of actions should be organized into groups with a beginning, middle, and end. Informative feedback at the completion of a group of actions gives operators the satisfaction of accomplishment, a sense of relief. (Schneiderman and Pleisner, 2005)
- *Permit easy reversal of actions:* as much as possible, actions should be reversible. This relieves anxiety, since the user knows that errors can be undone, thus encouraging exploration of unfamiliar options. (Schneiderman and Pleisner, 2005)
- *Support internal locus of control:* experienced operators strongly desire the sense that they are in charge of the interface and that the interface responds to their actions. (Schneiderman and Pleisner, 2005)

BEYOND USABILITY – PLEASURE WITH PRODUCTS

According to Green and Jordan (2002) the quality of the relationship between people and products depends on more than simply product usability. According to Green and Jordan (2002) alongside safety, wellbeing, comfort and ease of use, the pleasurably, transmitted by the object to the individual, is an important aspect in the search for quality.

Jordan (1999) describes a proposed hierarchy of user needs; *functionality*, *usability* and *pleasure*. A product will clearly be useless and dissatisfying to the user if it does not contain appropriate functionality. In order to fulfil the user needs on this level, understanding of what the product will be used for as well as the context and the environment in which it will be used is necessary. Once the users have got used to having appropriate functionality, they will then want products that are easy to use. To ensure usability, an understanding of some of the principles for usable design is required.

Being used to usable products, it seems inevitable that users will soon want something more, that do not only bring functional benefits but also emotional. To achieve product pleasurability requires an understanding of people and how they relate to products.

Green and Jordan (2002) states that people are more than just users, they have hopes, fears, dreams, tastes and personality. Their choice of products, and the pleasure or displeasure that products bring to them, may be influenced by these factors.

Whilst it is recognized that usability may be a key component of what makes using a product a pleasurable experience, it is likely that there will be a number of other factors which influence the pleasurably of a design. According to Green and Jordan (2002) these will include the aesthetics elements of a product and the experiential associations that users attribute to particular aesthetic properties, such as form, color and tactile properties.

According to Cooper and Reimann (2003) people like to change things around to suit themselves, changing things so it looks or acts the way they prefer, uniquely suiting their tastes. This way of personalizing objects gives individuality, and makes things more likable and familiar, more human and pleasant.

Creating pleasurable products requires the definition of user requirements specifications that define the person-product relationship holistically. Understanding user requirements on a holistic basis requires a rich understanding of the roles that products play in peoples lives. Designing pleasurable products presents challenges that go beyond those associated with assuring a products' usability, according to Green and Jordan (2002).

GESTALT LAWS

Monö (1997) states, that the aesthetics of a product can be seen as how the product gestalt expresses a message. The word gestalt, according to Monö (1997), can be described as: "*an arrangement of parts which appears and functions as a whole that is more than the sum of its parts*" (p. 33). "more than the sum of its parts" means, according to Monö (1997), that form, color, and material structure do not belong to the whole as isolated. The experience comes from how they work together and how they are influenced by each other.

There are several factors that help us to distinguish gestalts:

- *The proximity factor*: the closer it is, the clearer the gestalt (see figure 4). The proximity factor helps us to create gestalts when we group things.

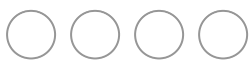

Figure 4: The proximity factor (Monö, 1997)

- *The similarity factor*: that is, the principle of common properties (see figure 5). Figures with the same properties create gestalts.

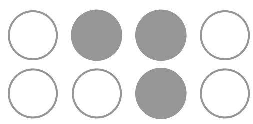

Figure 5: The similarity factor (Monö, 1997)

- *The area factor*: which makes us experience the gestalt more clearly the smaller the enclosed area is (see figure 6). Irrespective of whether the area is dark or light, it is the smaller area we see most easily.

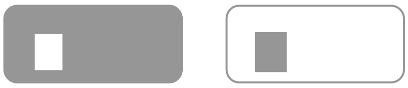

Figure 6: The area factor (Monö, 1997)

- *The symmetry factor*: symmetry creates gestalt (see figure 7). The lines in the middle, which are grouped symmetrically in relation to an axis, are seen as a whole.

Figure 7: The symmetry factor (Monö, 1997)

- *The inclusion factor*: lines that enclose an area are more easily seen as a whole (see figure 8).

Figure 8: The inclusion factor (Monö, 1997)

- *The good curve*: or the common determining factor (see figure 9). The good curve factor is what allows us to see the arrangement that makes the minimum change or break in straight lines or uniform curves or contours.

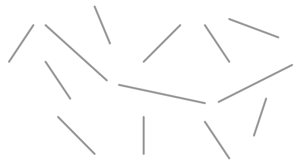

Figure 9: The good curve (Monö, 1997)

- *The common movement*: different elements makes them stand out as a gestalt (see figure 10). For example on a multi-lane motorway, the groups of cars moving in each direction create two gestalts.

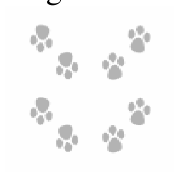

Figure 10: The common movement factor (Monö, 1997)

- *The experience factor*: requires that we observe conditions in the way we have learned from experience in order to be able to recognize a specific gestalt (see figure 11).

Figure 11: The experience factor (Monö, 1997)

According to Monö (1997) several of these gestalt factors can be summarized by the term simplicity, since we have a tendency to discern the simple most easily. The study of gestalts is a part of the study of form, the study of the way in which formal elements relate to one another, how they are organized into wholes, how they are arranged to create harmony, contrast is the basis for the study of the way in which forms are charged with meaning.

Each product mediate some kind of sign, the sign is not always the same. How the sign is interpreted depends on the specific person, meaning that the designer should make the sign as clear as possible so the targeted group of people understands the message the way it is supposed to. What we see, hear and feel of a product tells us something about it, but it’s not only about the products purpose, it could also be about the products use, properties and how it functions, according to Monö (1997).

3 METHODOLOGY

In this chapter we intend to describe our approach to this study. This will be done by explaining the methods used and the reasons for choosing them.

3.1 IDENTIFY NEED FOR HUMAN-CENTERED DESIGN

"Our design is based on the customer's needs and lifestyle along with the values that are represented by the Volvo brand."
(Volvo Car Corporation)

According to Norman (1988) good behavioural design should be human-centred, focusing upon understanding and satisfying the needs of the people who actually use the product. To be able to design a usable system that serves the users, through design built on users' needs and expectations, we realized the need for a process that has a user-centered approach.

ISO 13407 *Human-centered system design for interactive systems,* describes user-centered design to be a multidisciplinary activity and defines four design activities (understand and specify the context of use, specify user and organizational requirements, produce design solutions and evaluate design against requirements) that should be performed iteratively in a development process (see figure 12). (Gulliksen and Göransson, 2002)

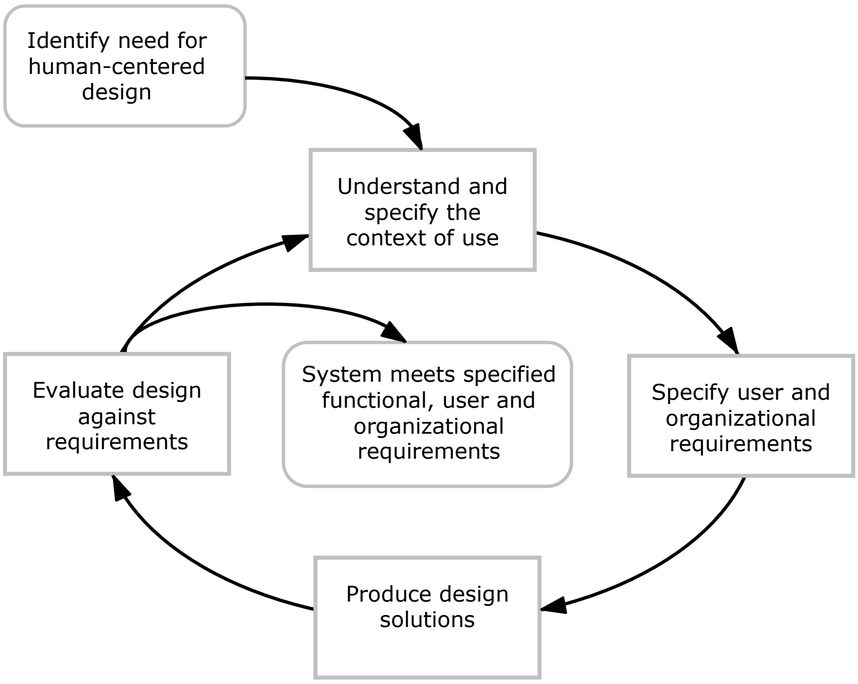

Figure 12: ISO 13407 Human-centered design process for interactive systems. (Gulliksen and Göransson, 2002)

In addition to the design activities in ISO 13407, Gulliksen and Göransson (2002) have suggested twelve key principles, which they consider a group has to follow to reach real user-centered design.

We attended to a few of these key principles in our work.

- It is necessary to cover all aspects in the development process, and different competences contribute to the whole, which is why *multidisciplinary teams* are one of Gulliksen and Göransson (2002) twelve key principles. To attain a high qualitative design solution, a multidisciplinary reference group was put together at Volvo Cars (with experts in the areas of; safety, HMI, ergonomics, interaction design and chassis), to support our work, with feedback and valuable input in the different stages of our process.
- It is important to prioritize what is best for the user, therefore the key principle *user focus,* to guide the development process on user needs, was attained by activities such as development of user profiles.
- Another key principle suggested by Gulliksen and Göransson (2002) is to use *prototyping* to visualize and evaluate ideas and design solutions with the end-users, which also was done.

Our user-centered design process, with the four design activities in addition to a few of the twelve key principles are described in more detail below.

A user-centered design process underlies the work of personalization, which according to Kramer et al. (2000) is the key to successful design and is based on the different choices that bring value to the end user. To attain user satisfaction and to be able to design user experience, and meet our goal to offer personalization possibilities, we have used personalization techniques in our user-centered design process as well.

3.2 UNDERSTAND AND SPECIFY THE CONTEXT OF USE

"To understand successful design requires an understanding of the technology, the persons, and their mutual interaction."

(Norman and Draper, 1986, p.1)

The first step in the user-centered design process is to determine the target user, according to Kramer et al. (2000). To ensure that the resulting system delivers value to the end user, models of the users' goals, beliefs and behaviours then must be generated.

According to Norman (1988), the understanding of the users' behaviours and the context of use is an important part of the design process, since if something is designed to support an activity with little understanding of the real work involved, it is likely to be incompatible with current practice. According to Norman (1988) users' do not like to turn aside from their learned habits if operating a new device with similar properties. To understand how people will use a product is essential for behavioural design, as well as to know what functions the product does and how it performs, according to Norman (1988).

Our first step towards a better understanding of the users in the context of use, we did a literature study. The literature concerned theories about how to understand driver behaviour and how it influences the safety in driving, together with what influences drivers in the driving context. It also concerned demands about HMI in cars and different design dimensions, to be able to design safe interaction and use, which will lead to usability and pleasure.

In parallel, based on the information we obtained from the literature, we specified the problem and developed a problem formulation and identified the concept design together with our reference group. Our work towards a good understanding of the context of use, in addition to the literature study, will be described in more detail below.

3.2.1 Understand the environment and technique

A good knowledge about the active safety systems was a basic condition for us. To get this knowledge we studied an outline of the technical specifications over the systems, the “one pagers” from Chassis department at Volvo Cars. An observation and test drive, in a special equipped Volvo S80 test vehicle, were done to attain a good understanding of the available active safety systems.

3.2.2 Understand the users and becoming users

A good approach understanding current and future users is learning about their goals and expectations, their behaviours in context and attitude towards the systems and the driving task. This information and thereby understanding, we got hold of through a semi structured *interview* and a *questionnaire*.

PARTICIPANTS

Our goal, for the *qualitative selection* of users (i.e. the selection of participants for the study, on which criterias they were chosen to participate etc.) was to find both users with experience of the active safety systems, and users without this experience. For various reasons, experienced system users were not available; therefore the selection of participants was partly QUIC-car[2] drivers from inside Volvo Cars, and partly “ordinary drivers” from outside Volvo Cars. The QUIC-car drivers could be seen as a kind of *lead users*, since they have a great experience of different systems in their cars and are used to verbalize their comments about the systems. A lead user is, according to Ulrich and Eppinger (2004), a user that experience new needs ahead of most users’, furthermore they are able to articulate their needs more clearly than typical users.

As Bell (2000) suggests the selection of participants should be done as representative as possible, therefore our selection were chosen on the basis of Volvos typical buyer. According to the Market Intelligence department the main Volvo customer is a 47 year old man, but since this man probably will let his wife drive the car from time to time, we did not only focus on the male population. In later time Volvo also develops cars for the younger population (Volvo C30), which is the reason why we thought it was important to include younger males and females as well.

To reduce the possible variables that may affect the way the interviewees express them selves, our aim were to only use interviewees with a university education. This selection was done since we saw the chances of getting more analytical and comprehensive opinions and comments due to interviewees with an academic experience.

[2] QUIC-cars are extra equipped cars which a few people inside Volvo Cars drive as company cars. The drivers of QUIC-cars should act and think as if they were real customers and had paid for their car, and regularly report their comments about the systems in their car to Volvo. The purpose of this is that Volvo Cars will get comments and find problems with new systems before the systems is introduced on the market and discovered by the customers.

We did the *quantitative selection* (i.e. the number of participants in the study) on the basis of when the stage of satiation is reached, that is when the information no longer is new. According to Ulrich and Eppinger (2004) ten persons are too few and fifty are too many, when for example interviews are used to identify user requirements of a product. We therefore chose to include twenty persons in our study.

INTERVIEW

Since we did not get hold of any experienced users and the access of the active safety systems is very limited, an observation was not a possible method for us to gather information from the users. Instead a semi structured interview was used (see appendix A).

One benefit with the use of interviews as a tool to attain understanding about the users is the flexibility. We chose the use of a semi structured interview, because of the possibilities to leave a certain freedom to the respondent to talk about his or her concerns, which is of great importance, according to Bell (2000). With a semi structured interview it is possible to follow ideas and use probing to get more information, adjust the questions to the interests of the interviewee and at the same time guarantee that the subject area and topic will not be lost, something that is not for sure in an open or unstructured interview, according to Bell (2000). Another benefit with some level of structure is that the analysis afterwards will get a lot easier, which is particularly important, when the time is limited.

When constructing the questions for the interview it is important to work systematically to ensure that questions are constructed around every sub area separately, in order to cover the specified problem. To make sure that the questions were constructed to generate information valuable for us to be able to meet our goal the questions were constructed from out of three areas of interest, covering our specified problem; *information presentation* (with questions giving information about the awareness and overview), *interaction and use* (with questions giving information about safe and intuitive interaction) and *personalization* (with questions giving information about the drivers relation to in-vehicle systems and their willingness to personally adjust the systems).

To plan the interview a technique named “the funnel technique” was used, which according to Patel and Davidsson (1994) is said to be motivating and activating to the interviewee. The funnel technique means that an interview should start with open and general questions, where easy and non-threatening questions are asked. The interview then gradually moves on to more specific questions with the more difficult questions at the end. According to Patel and Davidsson (1994), there are some issues to take into account when making the questions; the questions should be short and straightforward, they should not be leading and to avoid misunderstandings it should not contain jargon or language that the interviewee may not understand.

To be able ensure that our study is reliable there are several elements to take into account, according to Patel and Davidsson (1994). In interviews we have to think about that the reliability depends on the possible bias that may occur. Avoiding possible bias, we split the interview into two parts, so that one of us always took care of one part of the interview while the other one made notes. This was done, as Bell (2000) suggests, being able to avoid different accents which could lead to different reactions from the interviewees.

To ensure the quality of our questions we asked the members of our reference group as well as our examiner, to review the questions and ran a pilot study to identify possible problems in advance, as suggested from Bell (2000) as well as Patel and Davidsson (1994).

According to Patel and Davisson (1994), the time and place for the interviews should be, as far as possible, even if it may be unsuitable from interviewers' own point of view, decided on the basis and wishes from the interviewee.

As Patel and Davidsson (1994) suggest, we let the interviewee decide the time and place for the interview to take place, in order to easier get satisfied participants. We made sure that the interview environment was as similar as possible to keep the same conditions for all interviewees.

The use of some kind of representation of the product is according to Ulrich and Eppinger (2004) a positive tool to be able to generate information and to conduct an efficient dialog with the users. During our interviews we used a verbal scenario to expose the interviewees to a realistic context of use (in inner-city driving and motorway driving) to get reflections and considerations. The two different environments, inner-city driving and motorway driving was represented in the chosen active safety systems in the concept, namely; Lane departure Warning (LDW), Adaptive Cruise Control (ACC), Forward Collision Warning (FCW), Blind Spot Information System (BLIS) and Semi-Automatic Parking (SAP). To be able to in a clearer way explain the systems functionality, a poster in A4 format were used. Posters in A3 format of the use environment (both interior and exterior) were also used as representation with the aim to be used as inspiration for the interviewees. (All posters used are presented in appendix C.)

The documentation during the interviews was done by notes and sound recording (after approval of every interviewee). The recordings where done to use as a back-up if we were not able to note it all, or to check our notes afterwards if something was ambiguous or uncertain.

QUESTIONNAIRE

To attain a deeper understanding of the users' behaviours and how it influences the safety in driving, we used a questionnaire as a complement to the interviews (see appendix B). The questionnaire was thereby answered by the same persons that participated in the interviews.

The questionnaire was used to get hold of this understanding through understanding: *the attitude towards systems;* by measuring personality characteristics (since to be able to personalize the systems, we need to know what makes people want to personalize the systems and in which ways) and trust (since it influences the use of the systems) and *what influences the drivers in the context of driving;* by measuring personality characteristics (risk taking, sensation seeking and emotions) since that influences safe driving.

When using a questionnaire our possibility to control the reliability in advance is limited. The only thing to do, according to Patel and Davidsson (1994) is to ensure that the questionnaire is understood as we meant it to be. This is done by careful instructions to the questions, organizing them to make them easy to answer and using formulations that will not be misunderstood.

To ensure the quality of our questions in the questionnaire we asked the members of our reference group as well as our examiner, to review the questions and ran a pilot study to identify possible problems in advance, as suggested from Bell (2000) as well as Patel and Davidsson (1994). The questionnaire was created as fully standardized so that every person would answer the same questions in the same order. Each question had permanent answer alternatives and contained an attitude scale. According to Patel and Davidsson (1994) there should be a variation in the permanent answers alternatives, to keep up the motivation and to avoid to get stuck in an answer pattern. Since these questionnaires were not constructed by us, but validated measure methods, this suggestion was difficult to follow to be able to at the same time not diverge from the validated methods.

To be able to get information about the individual differences of the interviewee, different measuring methods were used (see appendix B: Questionnaire), as described below.

- To measure *personality characteristic* a Ten-Item Personality Inventory (TIPI) by Gosling, Rentfrow and Swann (2003) was used, which is a short version of The Big Five. Since our resources was limited this was a proper choice for us, Robins et al. (2001a) see Gosling, Rentfrow and Swann (2003) state that single-item measures ''. . .*eliminate item redundancy and therefore reduce the fatigue, frustration, and boredom associated with answering highly similar questions repeatedly''*.
- To evaluate *risk propensity* among our users we used an adapted version of the Domain-specific Risk-attitude Scale (DOSPERT) by Weber, Blais and Betz (2002). This scale assesses risk taking in five domains: financial decisions, health/safety, recreational, ethical and social decisions. We chose to adapt the scale to our environments, inner-city driving and motorway driving, consisting of ten questions. There were two reasons why we chose to adapt this scale, first and fore most, according to Weber, Blais and Betz (2002), risk propensity is highly domain-specific and depends on each situation; secondly, DOSPERT is a scale consisting of fifty questions which would be too time consuming to use.
- To measure *sensation seeking* which according to Dewar (2001) affect risk taking, we used Arnett Inventory of Sensation Seeking (AISS) by Arnett (1994).This scale consists of twenty questions.
- Subjective rating scales about *trust* where used, to measure the trust between the users and the car (as a system). Madsen and Gregor (2000) have constructed a measure instrument of human-computer trust, built on the measure instruments of Muir and Moray (1996). We have shortened this measure instrument of the authors to make it less time consuming.
- To be able to get hold of *the general mood* in these driving situations, we used two short situational descriptions over inner-city driving and motorway driving. Positive and Negative Affect Schedule (PANAS) by Watson, Clark and Tellegen (1988) was used for measuring the two important dimensions of mood.

To save time, both for us and for the interviewees, the questionnaire, together with a letter that described the purpose of the interview and questionnaire, were sent out in advance.

3.3 SPECIFY USER AND ORGANIZATIONAL REQUIREMENTS

Identifying customer needs is an essential part of the product development process, according to Ulrich and Eppinger (2004). The key benefit of identifying user needs is to ensure that the product is focused on user needs and that no critical user need is forgotten, as well as developing a clear understanding among the members of the development team of the users' needs in the target market, according to Ulrich and Eppinger (2004).

3.3.1 Specify user requirements

After gathering raw data from the users, the data should be interpreted in terms of user needs, according to Ulrich and Eppinger (2004).

To interpret the data a qualitative process was used, to be able to get a deeper understanding and with the purpose to understand and interpret it in its entirety. This is often not received through a quantitative process, according to Patel and Davidsson (1994). The crucial aspect whether a qualitative or quantitative research is pursued, is the problem formulation, according to Patel and Davidsson (1994). If the problem is about interpreting and understanding for example people's experiences or if an answer is sought to questions concerning underlying patterns, it is suitable to use a qualitative research approach with verbal analysis methods instead of statistical analysis methods. There are several different ways of carrying out a qualitative process, according to Patel and Davidsson (1994), meaning that it is often marked by the one carrying the process.

The data were interpreted continuously during our interviews, since the data then were easy to remember and to make the analysis work efficient and get as much as possible out of it. When the interview study was completed all data was printed and read several times. As next step in this process the gathered data was brought together so that the answers from each interviewee, for each question, were in one place. The data from the questionnaire was treated the same to be able to find patterns and connections among the gathered data, concerning different aspects related to our areas of interest.

The interpreted information was summarized in an *Ishikawa diagram*, also known as a *Fishbone diagram* or *Cause and Effect Diagram*, to specify the user needs and requirements. The diagram is named after its originator Kaoru Ishikawa in the 1960s, and is considered one of the seven basic tools of quality management and is often used within product design. (Bergman and Klefsjö, 1995) This diagram was used, to identify underlying user needs and requirements starting from four of the six M's which are often used as main causes, in a cause and effect diagram, for manufacturing industries (*Machine*, Methods, *Materials*, Measurements, *Mother nature* (environment), *Manpower* (man)) (Simon, n.d.). These four causes will together form a superior or overall effect within our three areas of interest; *awareness and overview*, *interaction and use* and *personalization and individual adjustments*.

On the basis of personalization, an analysis method can be used to learn the users' actions, methods of completing the tasks and the ultimate intention of the user, the users' goal. According to Kramer et al. (2000) it is important to understand that there are different triggers, processes and goals within different subtypes of users within the user target group. This is important since a given trigger can result in different goals for different users, and those goals can be accomplished through different tasks, and are therefore an important aspect in personalization.

After interpreting the data in terms of user needs, the needs should be organized into a hierarchy and the relative importance of the needs, which, in terms of personalization, is important to find out the ultimate desirable set of triggers, processes and goals - to be able to determine value to the end user, according to Kramer et al. (2000). On the basis of our Fishbone diagrams, we conducted a *specification of user requirements* organized on the basis of our three areas of interest, in terms of what the product has to do, as Ulrich and Eppinger (2004) suggest.

3.3.2 Specify organizational requirements

We attained the organizational requirements from a continuously dialogue with our reference group, so each of the representatives' area of interest was considered and set as requirement.

3.4 PRODUCE DESIGN SOLUTIONS

The concept development phase consists of a series of different steps, according to Ulrich and Eppinger (2004). After identifying the users' needs, the next step is to analyze competitive products. To attain inspiration and information from the competitors, we visited a series of different car retailers, to see different solutions of information presentation and interaction possibilities in the competitor's products, and also, through vendors, attain valuable information about the users' demands, interest and knowledge in active safety.

The third step in the concept development phase, according to Ulrich and Eppinger (2004) is to establish target specifications, which were done by using the specification of user requirements and the organizational requirements. The fourth step is to generate product concepts which were done by first making a *Function-Means Tree* (developed by Morgens, Myrup and Andreasen 1992), which purpose is to break down every function into sub functions, to find different possible solutions and from out of that generate concepts.

The Function-Means Tree together with our specification of user requirements where used in a design session with two persons from our reference group at Volvo Cars, experts in the areas of ergonomics and HMI. They individually sketched their view of the problem on the basis of our specification of user requirements and the Function-Means Tree. The sketches and the suggestions were discussed together to find benefits and disadvantages with them both. The suggestions were then further developed from out of two user profiles developed on the basis on behaviour and usage patterns collected in our interviews and questionnaires. The final concepts were then chosen as the fifth step in the concept development phase, according to Ulrich and Eppinger (2004). The concepts were then paper prototyped using Adobe Photoshop, and as a final step in this phase, the concepts should be tested, as were done and described in more detail below.

3.5 EVALUATE DESIGN AGAINST REQUIREMENTS

To ensure that the concept is understood by the users and that it conveys the users' mental model, tests and early prototypes could be used, according to Norman (1988), which is also important in terms of personalization according to Kramer et al. (2000). Norman (1988) states that if you can't understand it you can't use it, and if you learn it once you will remember it forever. When there is a lack of understanding, negative emotions kick in, and when people feel frustrated and out of control first uneasiness, then irritation, and if the lack of control and understanding persists, even anger, according to Norman (1988).

Concept testing can, according to Ulrich and Eppinger (2004) verify that customer requirements have been adequately met by the product concept, assess the sales potential of a product concept, and/or gather customer information for refining the product concept.

Ulrich and Eppinger (2004) recommend a seven-step method for testing product concepts; define the purpose of the concept test, choose a survey population, choose a survey format, communicate the concept, measure customer results and reflect on the results and the process.

One purpose with evaluating the prototypes was to see how well our concept complies with the goal and thereby the organizational requirements; to make the driver more aware of the active safety systems, to offer an intuitive interaction and possibilities to make personal adjustments, and even meet the scalability demands. Another purpose with the evaluation was to verify that the users' requirements were met by our design.

The first part of the evaluation was done by us through Norman's (1988) *seven usability principles*, *ten usability heuristics* by Jacob Nielsen (1993) and Schneiderman and Pleisner's (2005) *eight golden rules*. The second part of the evaluation was done with users, with six of the participants who attended in our interview, using our paper prototypes and a shortened version of our scenario of inner-city driving and motorway driving. We chose to use these persons because they already were involved in our problem and had insight and knew the function of the active safety systems in our concept. We used three men and three women, two of the participants where QUIC-car drivers from inside Volvo Cars. The age span was between 29 and 58. The selection of participants was done to get as similar conditions as for our interviews, the same division between sex and age. The third part of the evaluation was done together with the reference group to be able to evaluate the prototype against the organizational requirements and discuss possible refining suggestions.

After deciding which participants to use for the user evaluation we had a discussion of the paper prototypes together with our supervisors, this was done to determine possible problems, before the prototypes were evaluated with the users. An evaluation plan was then developed, as the third step for concept testing according to Ulrich and Eppinger (2004). To make sure every step in our evaluation for the paper prototypes were understood by the users we ran a pilot evaluation, as suggested by Bell (2000) and Patel and Davidsson (1994).

As suggested as the last step for concept testing according to Ulrich and Eppinger (2004), the results were interpreted and reflected on.

3.6 REFINE THE DESIGN

The most prominent design problems defined from the evaluations were discussed and refined to finally be developed to an interactive prototype in Macromedia Flash.

4 THE CONTEXT OF USE

According to Norman (1988), the understanding of the users' behaviours and the context of use is an important part of the design process, since if something is designed to support an activity with little understanding of the real work involved, it is likely to be incompatible with current practice. In this chapter the understanding of the users and the technique are presented.

4.1 THE ENVIRONMENT AND TECHNIQUE

The test drive together with the outlines of the system specifications, the ”one pagers”, made it possible for us to get a better understanding of the purpose with the systems in the context of use. To be able to use the systems and observe the systems in use, we gain a lot of valuable information and understanding.

4.1.1 Blind Spot Information System (BLIS)

BLIS is a system that helps the driver to detect obstacles in the blind spot, both on left and right side of the car. The system has a camera installed on each door mirror. If the system detects an obstacle in the blind spot a light warning is given on the front door post on the side of the car were the obstacle is detected. If the system is activated it will work from speeds over 10 km/h.

4.1.2 Lane Departure Warning (LDW)

LDW is a system that warns the driver if the cars is about to leave its lane. The system has a forward-looking camera installed. If the car detects that it is about to leave the lane it will give the driver a warning sound.

4.1.3 Forward Collision Warning (FCW)

FCW is a system that warns the driver if the car is about to collide with an oncoming car or a car in front, both a light warning and a sound warning is given. The light warning is given in a Head-Up Display[3].

4.1.4 Adaptive Cruise Control (ACC)

ACC is a cruise control system that automatically adapts to the car in front. The system uses radar mounted in the grille to adapt both speed and the pre selected time gap to the vehicle in front.

4.1.5 Semi-Automatic Parking (SAP)

The Semi-Automatic Parking system could help the driver with rearward parallel parking maneuvers. The system uses radar to sense the surroundings. First when the system is activated the vehicle starts looking for a free and appropriate parking space. When the vehicle have found a parking space the driver is told to put the car into reverse, let go of the steering wheel and give gas. The system handles the steering but the driver will have to give gas and brake.

[3] A Head-Up Display is an instrument projecting information on the windscreen.

4.2 THE USERS AND BECOMING USERS

The users and becoming users, our survey group, contained of twenty individuals, of which twelve were males and eight females, divided into two groups: *inside VCC* and *outside VCC*. The distribution was six males and four females in each group. The interviewees were aged between 26 and 58 years.

The group *inside* VCC were so called QUIC-car drivers. They drive approximately 40000-50000 kilometres each year, which gives them a big driving experience. The QUIC-cars driven were; Volvo V50, C70, and the new C30. The C30 drivers all had BLIS, but had only driven with the system for a few weeks. The interviewees were mostly educated engineers within areas such as; physics, electronics, machine and construction. There were also interviewees educated within design and programming.

The group *outside* VCC were people that worked in different technology areas, such as medical industry, IT management and system development etc. The cars driven among the interviewees from this group varied a lot, some examples are: Peugeot 206, Saab 9-3 (new generation), VW Golf and BMW 530. The interviewees in this group were educated within more varied areas such as; sociology, economics, medical technology, pedagogy, multimedia, IT and construction.

4.2.1 Interaction Design

Through the interviews our understanding about drivers' opinions about HMI in cars, mostly concerning information and interaction was increased. The results are presented below.

INFORMATION PRESENTATION

Information presentation can appear in different shapes; visual, auditory and tactile information. Thirteen people preferred the visual information presentation and the distribution between the groups: *inside,* and *outside* VCC, are equal (see figure 13).

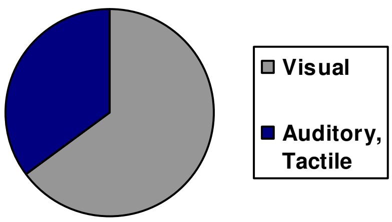

Figure 13: Type of information presentation preferred by interviewees.

One way to present the information visually was according a few interviewees through a graphical picture. The explanation for this might be that it is much easier to understand and interpret.

"Graphical presentation is fast and easy to interpret. Sound could be good but that kind of information takes more time to interpret"

One person interviewed mentioned that a graphical display that is too colourful and presents to much detailed information might be dangerous.

The regarded person mentioned that the information could be found too interesting and therefore might lead to problems keeping the eyes from the display. This might be a problem, but visual information could take different shapes and a few interviewees mentioned that symbols are great for presenting information, while others mentioned text messages as good ways to present information. Anyhow, when to explain different warnings and from where they arise. So the interviewees seem to want text messages to complement the explanation of the situation and not for a quicker recognition.

"I want a text message that explains why the warning arises"

The interviewees also mentioned that text message should be in combination with something else. The majority of the interviewees wanted the information to be visual, and the information should be presented in the field of view, this was probably so they could maintain concentration and focus on driving.

"The information should be placed so I do not have to loose too much focus on the driving task"

According to some of our interviewees both Citroën C4's and Saab 9-3's highly placed displays (central above the dashboard) were mentioned as a good place to present information. The explanation might be that a sudden change of the information on the display could be discovered even if the driver does not look directly at the display. One interviewee mentioned that the most important information should be presented as high and central as possible, meanwhile the less important information can be moved to the sides. Therefore it is and will be important to design so the presented information supports detection, understanding and responding to not increase the risk of traffic accidents.

The majority of the interviewees mentioned that information should not be presented if it is not important for the situation. This might depend on the increased information that might affect the concentration and focus on driving.

"The systems should do a risk judgement and give me the information that is important, so the amount of information does not become too big"

Sound as information was preferred by a few interviewees, this was probably because it is not avoidable. Meanwhile females reject sound because it scares them.

One interviewee mentioned that tactile information could be advantageous when you need to create attention in fast and intuitive situations; this is probably because tactile information awakes you. According to one interviewee advantages with tactile information is that it do not separate persons on the basis of their functionality disabilities. Tactile information could according to the interviewees be presented either in the steering wheel or in the seat, and it would probably work in systems like LDW, FCW, and BLIS. One interviewee mentioned the usability connection between steering wheel vibrations with the warnings in different computer games.

"Information can be presented with vibrations in the steering wheel. This can be connected to warnings from computer games – which will be intuitive, especially for the younger generation"

(male, age 30)

On the other hand, one interviewee from the older generation mentioned that tactile information was not appropriate since it made the regarded person think that the car was broken.

Issues directly connected to the specific systems were mentioned, as;

- The Lane Departure Warning (LDW) system could according to a few of the interviewees have a two-step warning; at first a light warning, followed by a sound warning when the situation gets more critical. This might be connected to the statement that a few interviewees get scared of sounds. The light warning might remedy the need for a sound warning if the driver discovers the problem at an early stage.
- The light indication for the Blind Spot Information System (BLIS) has according to a few interviewees a logical placement, because it is in the field of view for the particular situation. Even that the light indication comes from the corresponding side of the car, where the warning arise is appropriate. A few interviewees wanted some kind of additional information for BLIS, as for example a text message or a sound, which could be presented in the combined instrument panel or in a Head-Up display. There were also a few interviewees mentioning that the system should give any information to the driver if the driver has not turned on the directional indicators or made a big steering wheel movement.
- Numerous of the interviewees mentioned that comfort systems like Adaptive Cruise Control (ACC) should not be using sound for presenting information, though the sound should be used in systems presenting more critical information, like warning systems.
- Important for several of the interviewees were that information presented from the Forward Collision Warning (FCW) system should be: *"fast and make you react and act"*.

In comparison with other studies

According to Galitz (2002) one of the advantages with graphical user interfaces is that symbols (graphic) can be recognized faster and more accurately than text. In our study we can see that people prefer visual information presentation. Galitz (2002) also states that a graphical user interface could easily be augmented with text displays where limitations in the graphical design exist. We could see in our study that the interviewees wanted complemented text.

Dewar (2001) state that more complex displays should be placed higher on the dashboard to minimize the time for glancing at the display when focus should be on the driving act. As interviewees in our study wanted important information in the field of view, our study shows the same conclusions. Dewar et al. (2001) state that driver error is often connected with failure to detect, understand or respond to information, this is often a contributing cause to traffic accidents. Important information should for that reason be designed so it will not contribute to traffic accidents. In our study the interviewees did not want information if it were not important for the situation because it is superfluous information and might distract the driver and the drivers' focus on driving.

Even if the interviewees mostly wanted the information to be visual there were interviewees that mentioned that tactile information could be advantageous when you need to create attention in fast and intuitive situations, especially if the information should awake you. According to Burnett and Porter (2001) tactile information should be used inside cars thus older people with decreased visual and auditory capabilities, will gain a lot from haptic information.

One of the interviewees mentioned the advantages with tactile information, as it does not separate persons on the basis of their functionality disabilities.

INTERACTION AND USE

To interact and use different systems might be done in different ways. Buttons and handles are probably the most common way of interaction in vehicles. Touch screens and voice recognition are new ways to interact and not yet that common.

”The interaction should be a physical act, because it creates a feeling of control”

That the interaction tool gives a physical feedback was important for a few of the interviewees, because it creates a feeling of control. The same interviewees also considered that buttons provides a good feedback, both audible and tactile. A few interviewees also mentioned that touch screens do not give the same physical feeling and feedback as buttons. While a few of the interviewees consider that buttons and handles are good, others mean that they make you loose concentration.

According to several interviewees, focus on driving is best maintained if the placement of controls is on or by the steering wheel.

“I am used to interact with my hands. Functions that let me have my hands on the steering wheel are good.”

A few interviewees also mentioned that several system menus today have too many choices, which is disturbing because it is difficult to find what is searched for and hard to handle that amount of information while driving. To solve this problem, one interviewee mentions that:

“Functions used more often can have dedicated buttons while functions that are used more rarely can be embedded in the menu system.”

The majority of interviewees do not think that they fully maintain focus on driving when they interact with different systems. A few interviewees mentioned loss of focus when needing to navigate through to many menu alternatives and there are too many button pushes. Focus is also lost if a control is out of reach, the interaction should therefore according to a few interviewees be that intuitive that it could be handled without looking.

Buttons and handles that are used for navigation are not always logical. Interviewees in the group inside VCC mentioned that buttons in the integrated phone and navigation system in the Volvo P1 platform[4] are too small. The same group also pointed out that the navigation system was difficult to use and the reason seemed to be that there were too many choices in the menus.

[4] The Volvo P1 platform is for either front or all wheel drive, and is today shared among the Volvo S40, V50, C70 and from 2007 even the all new C30.

A few interviewees expressed their doubtfulness about using the Adaptive Cruise Control (ACC) since it affects them as drivers negatively, meaning that their concentration and focus is lost.

"I would not like to have this system. I do not understand its purpose since it puts me in a situation were I am not active as a driver."

Voice recognition might be good to maintain focus according to a few of the interviewees, but they all agreed that the technology must be evolved. (The judgement of the voice recognition was often connected to the voice recognition in the mobile business.)

A few interviewees pointed out that they like the memory functions on the seats but also mentioned that it could be a bit difficult to use and understand. Several interviewees like the memory function since it leads to increased number of times of doing the same procedure.

In comparison with other studies

Using feedback in the right way can provide the necessary visibility for user interaction, according to Norman (1988), Nielsen (1993), and Schneiderman and Pleisner (2005). In our study we could see that interviewees wanted the feedback to be physical because it makes it easier to interact without looking.

Dewar (2001) states that, when things are not located or do not operate as expected, driver workload and perception-response time increases. Further, according to Dewar (2001), the placement of controls should be easily seen and reached, which is in line with our study were several interviewees mentioned that focus on driving is best maintained if the placement of controls is on and by the steering wheel. According to National Highway Traffic Safety Administration (NHTSA), (Young et al. (2003)) there are four different kinds of distraction. One of them is the visual distraction, which means that you need to look at something else. To lower the possible visual distraction the placement of controls should be so that the driver does not need to change focus. This can be seen in our study because the majority of interviewees have problem maintaining focus in driving when interacting with different systems.

Dewar (2001) states that the auditory mode will be more used when technology advances; both voice controls and auditory displays might relieve the visual sense of input to be processed, and decrease the workload. According to a few of the interviewees voice recognition might be good to maintain focus but they all agreed that the technology need to be better.

4.2.2 Individual differences

The questionnaires were used to understand individual differences and how different driver behaviours affect safety in driving. To be able to give the drivers the possibility of system personalization we needed to know what affect if the driver do personalization or not. Through the questionnaire our understanding about driver behaviour and how it affects safety in driving was increased, as well as insight about drivers' relations to the car and different systems within. The results are presented below.

EMOTIONS

Through descriptions of inner-city driving and motorway driving the general mood in these driving situations were attained as positive and negative emotions relates to safety in driving.

Sex differences

According to our survey females have more positive emotions both in inner-city, and motorway driving, than the males. The females also show on more negative emotions than the males, meaning that females generally have more emotions than the males. Females may not have the same driving experience as males which may indicate that females are more vulnerable when they get in situations they are not used to and these situations are the origins to more emotions, and more negative emotions.

Inner-city driving vs. motorway driving

General both sexes have more emotions (both positive and negative) in inner-city driving than on motorway driving. The inner-city driving often means crossings and traffic lights, line changes and large quantity of information, while motorway driving often means high speed, long distances and monotonous driving. The inner-city environment might be the originator to a lot of emotions, both positive and negative, because there might be more emotional traffic situations in inner-city driving.

Group differences

Differences were also found between the two groups of interviewees; *inside* VCC and *outside* VCC. It shows that the group of interviewees from *inside* VCC has more emotions when it comes to different traffic situations, which also means that they have more negative emotions. The explanation to this phenomenon might be that the interviewees *inside* VCC drive more, which logically also gives more space for emotional traffic situations.

The females *inside* VCC have a lot more positive emotions than the females *outside* VCC. It could also be seen, that females *outside* VCC have more negative emotions in inner city driving than the females *inside* VCC. In this case, the females *inside* VCC have a company car (QUIC-car) and drive a lot, which the females *outside* VCC might not do to the same extent, to drive more gives also big opportunity to more emotions in traffic.

Specific Emotions

The interviewees consider themselves to be more *interested, attentive, active* and *alert* in inner city driving than in motorway driving. They also consider that they are more *indignant, nervous,* and *anxious* in inner city driving than in motorway driving. The females independent of group experience that they are more anxious in inner-city driving than the males, while the males independent of group experienced that they are more interested in motorway driving than the females. It turned out that the females experience to be more active in motorway driving than the males. It can be seen in our interview that females consider themselves more *indignant, nervous,* and *anxious* in different traffic situations. These are the emotions that they experience in this traffic situation, and maybe a low driving experience might lead to these kinds of feelings.

In comparison with other studies

Lewelt (2003) see Ström et al. (2005), shows in a study that the most frequently reported emotions in the driving context was pleasure (more than half) and anger (nearly a quarter), which is shown in our study as well.

The majority of the interviewees show to be extraverted and have high values on positive emotions, which is in similarity with Rotbarth (n.d.) who states that extraversion shows overlapping with positive emotions (happiness).

According to Dewar (2001) females have less driving experience than males, are more cautious, drive more short trips and drive more in daylight. In our study females show on more emotions, both positive and negative, which may be explained with that females are more vulnerable when they get in situations they are not used to and these situations are the origins to more emotions. It can be seen in our study that females consider themselves more *indignant, nervous,* and *anxious* in different traffic situations, which might be an affect of what Dewar (2001) states.

RISK TAKING

Driving is the most common and best-known risky activity, in the modern society, according to Svensson (1981), and therefore an important factor to understand to be able to understand driver behaviour and how that affects the safety in driving.

Sex differences

In the group *outside* VCC the females were slightly more risk taking than the males, it was the other way around in the group *inside* VCC.

Group differences

Both the females and the males from the group *inside* VCC show higher values on risk taking than the females and the males from the group *outside* VCC. As stated before the interviewees from the group *inside* VCC drive a lot, probably more than those from the group *outside* VCC. Driving more results in more experience and might therefore result in feeling more in control.

Personality traits

We made pre-assumed connections between conscientiousness and not being risk taking, since a person scoring high on conscientiousness is; reliable, punctual, scrupulous and preserving, this did not agree with our study. Pre-assumed connections were also made between a neuroticisms and low values on risk, because a person scoring high on neuroticism is; worrying, nervous and insecure. This assumption did not either agree with our study.

Relation between risk taking and personal adjustments

In our modified DOSPERT scale (see appendix B) for measuring risk, there were two statements that were especially interesting, because they show on performing secondary tasks while driving, which increase distraction and therefore is a risky behaviour in traffic. The two statements were:

I do not talk in my cell phone while I am driving in the city and *I interact with the car's different systems while driving in the city and on the motorway.*

Nearly half of the interviewees do talk in their mobile phones while driving in the city and slightly more than half of the interviewees interact with different systems while driving.

We assumed that risk taking might influence the willingness to do personal adjustments while driving, since interacting with different in-vehicle systems is a risky behaviour and might affect the drivers focus on the road. Since our study shows that the majority are willing to do risky secondary tasks while driving, they might also do personal adjustments while driving. This shows that risk taking might influence drivers' willingness to do personal adjustments while driving.

In comparison with other studies

Persons that feel in control over a situation are more likely to take risks according to McCrommon and Wehrung, (1986) see Ström et al. (2005). The illusion of control and the overestimation of the degree of control increases with driving experience, according to Rothengatter (2002). These statements are in agreement with our study, which indicates that the drivers inside VCC have more driver experience and are more risk taking.

Dewar (2001) state, that sensation seeking is a factor that can affect risk taking to reach these sensations. In our study we cannot se any connections between sensation seeking and risk taking (in traffic).

According to Dewar (2001), males are generally more risk taking than females on the road, which is not in agreement with our study.

According to Nicholson et al. (2005) see Ström et al. (2005) an extraverted person, especially sensation seeking and openness are individual characteristics that have been studied as it relates to risk taking. This can be seen among the majority of interviewees in our study.

TRUST

The understanding about the drivers' relation to the car and the systems in it is an important part of understanding driver behaviour. Drivers' trust in the car is a crucial aspect in the relation between the driver and the car.

Group differences

Females from the group *inside* VCC are those that show the highest values on trust between all the groups. There were big differences in trust between the two female groups, where the females *inside* VCC show on higher values on trust. The males *outside* VCC have higher values on trust than the males *inside* VCC, the difference between the two male groups were not as big as between the female groups.

Sex differences

In the group *outside* VCC the males are those that show highest values on trust. *Inside* VCC the females are those that show the highest values on trust in this group. We believe that they probably trust the car that it performs its task.

Personality traits

We made pre-assumed connections between agreeableness and trusting systems, since a person scoring high on agreeableness is; trusting, forgiving, and gullible. This is in agreement with slightly more than half of the interviewees in our study.

Relation between trust and interest of technology

In our survey, we can see a connection between interest of technology and trust. A big interest of technology, according to us, might affect testing the systems and therefore trust is increased, and you might do personal adjustments to the systems.

This cannot be seen clearly through all the interviewees, but a tendency can bee seen that the females *inside* VCC show much higher values on trust, as well as bigger interest in technology than the females *outside* VCC. The difference in trust between the two male groups is not as big as the difference between the two female groups. This might depend on that males are often more interested in technology and different systems than females in general.

In comparison with other studies

According to Muir and Moray (1996) trust in systems depends on if you use the systems or not. We noticed this quite clearly in our study when for example the majority of the interviewees mentioned that the Semi-Automatic Parking system made them to feel insecure. They all mentioned that trust in a system like this is very important, and some of them also pointed out that they would be doubtful in trusting a system like this.

“I should not trust this system, should not dare trusting it.”

Another example showing that trust and use is closely connected is opinions on BLIS. A few interviewees mentioned that the system cannot be trusted since it flashes all the time.

”I do not yet consider BLIS to be reliable, all systems need to be reliable for me to trust and to use them”

This has probably to do with the system's technical competence. The system performs fine until the person considers the system to drop below a certain point. In this case the system might become a distraction to the driver. According to Rudin-Brown and Noy (n.d.) trust in machines has to do with the technical competence of the machine, and users expect it to do its job correctly.

If your trust in a system is high you might trust the system to be correctly set and that it works, as it should. This is according to Muir and Moray (1996) the dynamic side of trust. They state that the person’s trust in systems is high in the beginning of use. The trust might change during experience and when the system performance not longer satisfies the user the trust is decreasing. So, persons that have high trust in a system and not use the system will therefore not experience a decreasing system performance.

4.2.3 System personalization

To be able to offer system personalization it is important to understand what factors affect this, as well as what makes a person willing or not willing to personally adjust systems. Individual differences, as described in the chapter above do affect the users’ willingness to do personal adjustments.

Fifteen out of twenty interviewees comment that they do not do personal adjustments in different systems or they only do it once (see figure 14). There is no significant difference between the groups: *inside* and *outside* VCC.

In contrast, to how many that does not do personal adjustments to the cars' different systems; almost everyone wants to have the opportunity to do so, which probably is connected to the need for control.

"I like to try. I often do changes to see what happens, but often I change back to default because it feels good. Sometimes I keep some changed setting"

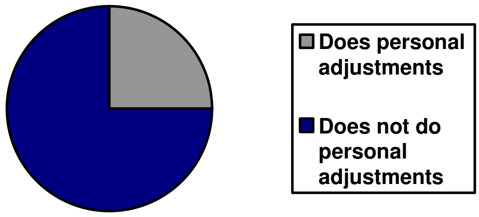

Figure 14: The number of interviewees doing personal adjustment to in-vehicle systems

Common among the interviewees was that they wanted the opportunity both to do personal adjustments to the warning sound type and the warning sound volume to the safety systems.

"I want to be able to do personal adjustments of what type of warning I want, so I easily can distinguish which warning it is for a particular system"

To be able to do personal adjustments to the warning type and warning sound might be of interest because it makes the interviewees feel in control and they think that they will recognize the warning better if they have chosen it on their own.

A few interviewees were sceptical for doing personal adjustments to future active safety systems because they do not think they are the right person to do settings in a system like that and to be sure that the system is still safe.

"I as a driver am not the most competent person to do personal adjustments in these systems"

(male, inside VCC)

"I do not think that you should need to do personal adjustments in these systems, I even think it could be dangerous because it is situations I do not understand, and then I am not the right person to do these personal adjustments. I assume that the experts know what is best!"

(female, inside VCC)

The opinion if there should be any differences in possibilities doing personal adjustments before driving and during driving is split. Many of the interviewees think it is up to the driver to decide, since the driver should have the sense to decide on his own. To restrict the drivers' possibilities to do adjustments only while not driving, can affect the drivers' role as operational and in control of the car.

Does not do personal adjustments

The interviewed females *outside* VCC do not do personal adjustments to different systems, or only once. Two of them have low values on trust, which might indicate that they do not trust the systems, which probably affects their lack of interest to personally adjust them.

They also mentioned their low interest of technology during the interview. The other two have high values on trust, which might indicate that they trust the systems to be correctly set from the manufacturer. Three out of six males *outside* VCC, do not personally adjust systems, or only once. This may be explained with their interest of technology and knowledge, which conducts to that they know what and why they adjust the systems.

Three out of four females *inside* VCC do not either do personal adjustments to different systems, or only once. All these females have high values on trust which may indicate that they trust the settings to be done correctly from the manufacturer. Five out of six males, *inside* VCC, do not do personal adjustments to different systems, or only once. This may be explained with their interest of technology and knowledge, which conducts to that they know what and why they adjust the systems. Otherwise this may be explained with their relatively high values on trust which may indicate that they trust the settings to be done correctly from the manufacturer.

Does personal adjustments

There are only five out of twenty interviewees that personally adjust different systems. Three of these are males from the group *outside* VCC. Their big interest of technology might affect their willingness to personally adjust different systems.

The other two are one woman and one man from the group *inside* VCC. The female mentions that she has a big interest in the systems, which might be the reason why she does personal adjustments to them. Presumably the male also have a big interest of technology but shows to have fairly low trust to the car, which might indicate that he is not satisfied with the settings done from the manufacturer. Perhaps, it makes him feel the need to do his own personal adjustments so they fit him. He also drives in varying traffic situations and cultures, which might affect that he needs to do personal adjustments to the systems to adjust them after the varying traffic cultures.

Four out of five that do personal adjustments to different system also points out that they do personal adjustments during driving. This group of people will probably not want any limitations on what settings are possible before and during driving.

Group differences

There are more interviewees from the group *outside* VCC that do settings to the systems. The interviewees from the group *inside* VCC drive a lot, approximately about 40000-50000 kilometers every year. This is probably less among the group *outside* VCC.

This might indicate on the tendency that those that drive a lot have become tired of doing personal adjustments to the systems.

"I think that functions and systems are charm of novelty, it is fun until you become tired of them, and then you do not do any personal adjustments"

(female, inside VCC)

Maybe the charm of novelty can be something that makes the people *outside* VCC wanting to do personal adjustments to the systems to a greater extent.

In comparison with other studies

According to Cooper and Reimann (2003) people like to change things around to suit themselves, changing things so it looks or acts the way they prefer. This way of personalizing objects gives individuality, and makes things more likable and familiar.

The majority of the interviewees in our study would like the opportunity to adjust the systems to suit them selves, as Cooper and Reimann (2003) state they would like the systems to act the way they prefer.

Several interviewees would like the opportunity to personally adjust warning sound and sound volume. According to a study made by Wang et al. (2006), even if the participants preferred a specific warning sound and volume their performance showed no differences in reaction time and accuracy. So to give the driver the ability to set the warning sound might get the driver a feeling of control but it does not increase the performance.

4.3 USER AND ORGANIZATIONAL REQUIREMENTS

The information gathered from the interviews and questionnaires is the base for creating the user requirements. The organizational requirements were gathered in a close dialogue with our reference group. The user and organizational requirements are more deeply explained below.

4.3.1 Specification of user requirements

To create a better view of the gathered information about the users, it was summarised in three Fishbone diagrams, to use as a base to specify the user requirements. These diagrams were divided into the three areas of interest; *information presentation* (see figure 15), *interaction and use* (see figure 16), and *personalization* (see figure 17). Each fishbone diagram is created out of four main factors that might affect the problem; man, machine, environment and materials. Each main factor has different causes.

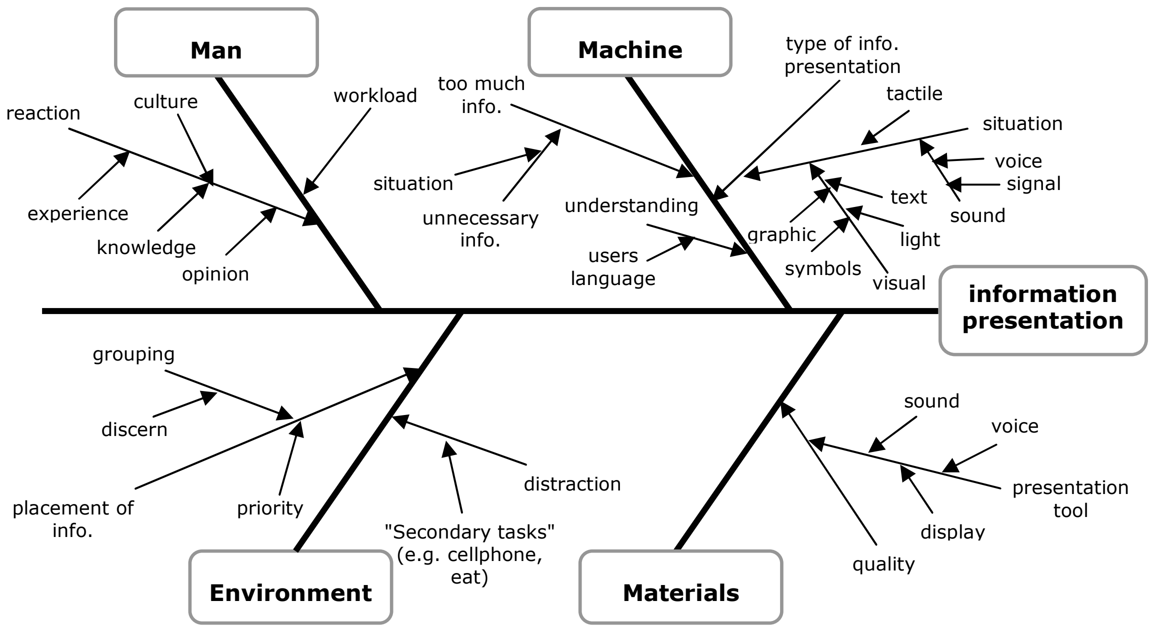

Figure 15: Fishbone diagram for information presentation.

Important for many of the interviewees, was the placement of information, how the information is prioritized and grouped. Too much information is not good and the information should be important for the situation, which will decrease the amount of superfluous information.

As a person you will also react on information in different ways depending on your experience, culture, knowledge, and personal opinion. Information can be presented in different ways; visual, auditory and tactile, which of these that is preferred depends on the situation.

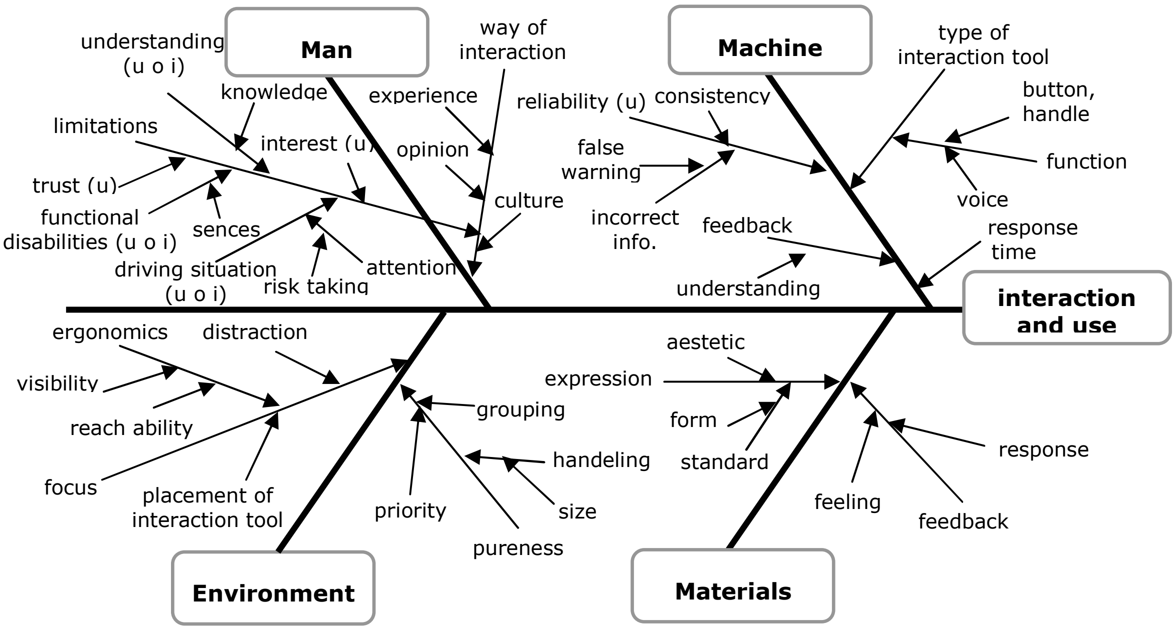

Figure 16: Fishbone diagram for interaction and use.

How people prefer to interact and use different in-vehicle systems depends on different personal factors. The understanding of a system is connected to the knowledge of the system, and if the person does not fulfil any of the factors, this might be seen as a limitation, and the system might not be used.

How well a person can maintain the focus on the driving task while interacting and using a system will be affected by the placement of the interaction tool, the ergonomics and the distraction, which arises from interacting and using different in-vehicle systems. The interaction should also give feedback; this is for increasing the understanding.

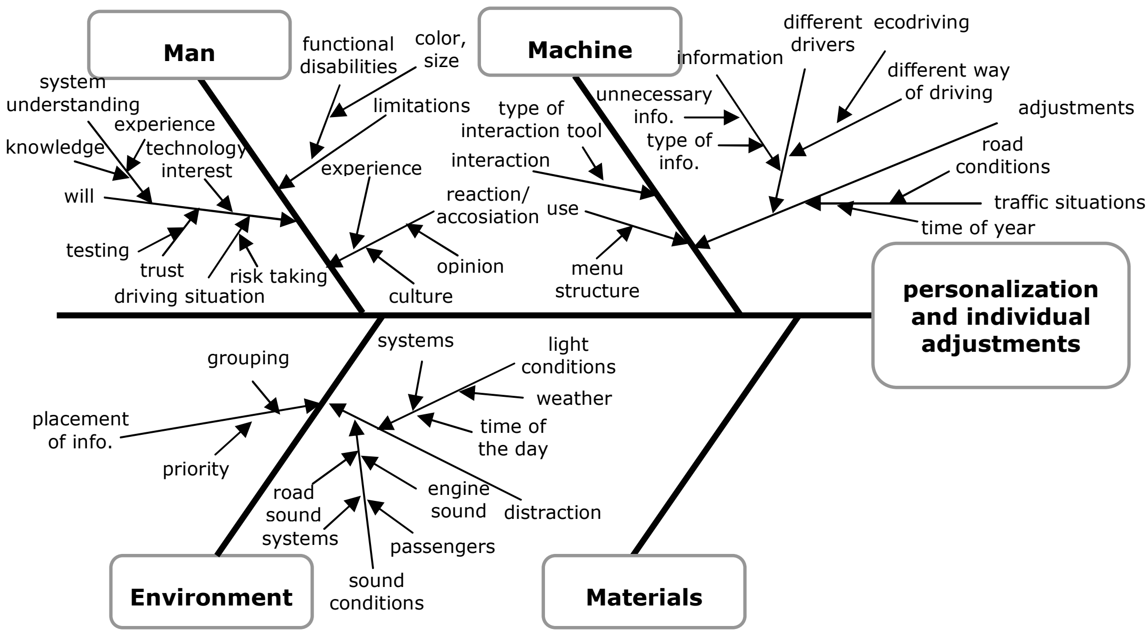

Figure 17: Fishbone diagram for personalization.

Willingness is the most fundamental aspect if a person should do personal adjustments to systems or not. System understanding, interest of technology, trust and driving situations are all factors that affect the willingness to do personal adjustments. There are also environmental factors that affect if a person wants to do personal adjustments. This could be light conditions (weather, time of the day etc.) and sound conditions (road sound, engine sound etc.). Why a person want to do personal adjustments might depend on the information that is presented, different persons want different information.

Well structured fishbone diagrams helped us to create a specification of user requirements, divided into the three areas of interest: information presentation, interaction and use, and personalization, presented below.

INFORMATION PRESENTATION

The information should be presented visually; using symbols, graphics, text and light. This is because the visual information stays and is easy to understand and interpret.

The information should be presented in the field of view, this can be done either by present the information in the kombi instrument (speedometer, tachometer) or in a Head-Up Display. This should be done so focus can be on driving.

The information should be presented when it is needed, to avoid superfluous information, but also to easier understand the information.

The information should be presented clearly, this can be done by using the right size and placing, but also by using the users language, and to use pureness, grouping, entirety, simplicity, and esthetical. This should be done to easier understand, separate, and easier to use the information.

The information should give understanding to create a clear overview, increase usage, and to create trust. Logical grouping, standards and symbols can do this.

The information should be consistent to create understanding and trust. This could be done through expression, form and placing.

The information should be prioritized and presented out of its relevance for the situation to avoid superfluous information and to create quick reactions for the driver. Using IDIS and CoDriver should mainly do this. Further, the warnings should be designed so they are of other information than visual, so the driver could notice and react intuitive. The warnings should use sound or tactile information. The warnings are best when they are in combination with explanatory text messages.

INTERACTION AND USE

The interaction should be logical so it is easy to use, easy to learn, but also so it increases the usage, and lower the distraction, which means increasing focus. This can be reached by using standards, logical expressions (button = push, handle = turn), and to take different experiences and cultures into account.

The interaction tool should give the user feedback to create understanding, and to give a feeling of control. This should be done by form and feeling

The interaction tool should be placed so it is easy to find and interact with, to maintain focus on driving. Placing the interaction on the steering wheel or close to the hands can do this.

The interaction tool should have a clear form so it is easy to find, easy to use, decreases distraction, but also easy to understand the connection between the interaction tool and the information. This can be done by using right size, right placing, logical labelling/symbolic, logical expressions (the interaction tool shall express what the function does), but also to take different cultures into account.

PERSONALIZATION

The information and interaction should be adjustable because different people have different experiences, comes from different cultures, have different interests, but also to satisfy different needs at different drivers and so it should be easy to use. This can be done by adjusting out from personal constraints and personal likes, adjust the information: possibility to turn off superfluous information and to choose type of information (menu structure (easy/advanced)), adjust system behaviour: from out of traffic situation, sound/light, possibility to save settings.

4.3.2 Organizational requirements

The organizational requirements have been developed in cooperation with our reference group at VCC, and are thereby related to each representative's area of interest.

The main organizational requirements are that;

- the HMI solution should create understanding about, and make the driver more aware of, the car's active safety systems.
- the driver should be able to in an intuitive way interact with the HMI, and do personal adjustment to the car's active safety systems.
- the HMI should be flexible so it achieves the scalability demands.

5 DESIGN SOLUTIONS

This chapter presents the design solutions, based on the user and organizational requirements together with our understanding of the context of use.

5.1 ANALYSIS OF COMPETITIVE PRODUCTS

As the first step in the developing phase competitors' products were analyzed. The competitors visited to attain information and gain inspiration about their solutions in the area of active safety were; BMW, Mercedes, Audi, Citroën and Lexus. We noticed that to get the level of safety that Volvo Cars active safety systems means, you will have to buy a competitive car for almost one million Swedish crowns.

5.1.1 Active safety

BMW and Mercedes offer a few different active safety and comfort systems. Examples are Night Vision (which is an infrared camera that detects objects and presents a picture in different grey tones), Adaptive Cruise Control, Brake Assistant, and Park Assistant systems.

"Our customers do not ask for active safety systems and we vendors do not inform them that much either, the active safety systems are expensive so we often recommend other equipment to the customer.

Big and heavy cars are safe anyway! "

(BMW vendor)

The BMW vendor think that a Head-Up Display is good from a safety point of view, while the Mercedes vendor advocate Night Vision in the area of active safety systems, *"night vision is the big thing now"*. The vendor at Mercedes told us that the interest in these kinds of safety systems increases among the customers, but they often do not prioritize to put money on them.

"Our customers ask for active safety systems, but when the purchase is about to be done it is usually not that interesting anymore. Since the active safety systems are expensive the only customers who prioritize these systems are those who buy one million Swedish crowns cars."

(Mercedes vendor)

Lexus is also contributing to the active safety segment. They offer among other, Adaptive Cruise Control with in built Forward Collision Warning system, and Park Assistant. Citroën's contribution to active safety is, among other, a Lane Departure Warning system, which detects an unintentional lane change, and gives a vibration in the car seat on the side corresponding to the direction of vehicle drift.

Adaptive Cruise Control, Brake Assist and a Park Assist are examples of active safety systems in Audi. Further, Audi also offers a system called Side Assist which is a system that warns the driver when there is another vehicle moving through the blind spot. When a vehicle moves into the blind spot, a vertical row of LED lights on the side of the outside rearview mirror will glow. If the driver ignores the lights and hit the turn signal lever to change lanes, the LED's become brighter and flash.

5.1.2 Interaction and use

BMW has their iDrive system that handles most of the cars' different systems. The system is built around a handle located in the space between the front seats and a large colour display mounted high on the dashboard. The menu is divided after the four points of compass and the menu have four main categories; Climate, Communication, Navigation and Entertainment. The iDrive system does not have any dedicated buttons for fast access to different functions. The iDrive system is according to BMW PR material, "*an innovative system that should help the driver to concentrate on the driving to the maximum*". The most important information can be projected on the window with the Head-Up Display that present the information in the sight of view.

In the Mercedes S-class, Mercedes have further developed their information system COMAND. The system is very similar to the BMW iDrive system. The system is built around a handle, located in the space between the front seats, and all the information is presented on the large colour display mounted high on the dashboard, close to the drivers' sight of view. The display can be pointed either at the driver or the front passenger. On the display the driver can choose with the COMAND handle, which information that should be presented on the display. With the handle, the driver can scroll between the different menu choices and confirm with pushing the handle. The system has some dedicated buttons for frequently used functions. The system also offers a programmable button that could be used for whatever the driver wants.

The Citroën C6 does not have a similar system as BMW and Mercedes. They have a high mounted dashboard multifunction display that handles all of the car's comfort systems. Most of the functions can be handled from the steering wheel. Citroën C6 also offers a Head-Up Display that can show the most important information for the driver, such as; speed, navigation, and different warnings.

Most of the information in Lexus is operated in a multifunction display, mounted high on the dashboard. Around the display there are dedicated buttons for different systems.

Similar to BMW and Mercedes, Audi have an information system (manoeuvre system), named Multi Media Interface (MMI). With a handle placed in the space between the front seats, the driver can handle the different systems. The main categories of the system are: Entertainment, Communication, Information, and Settings. The system has eight dedicated function buttons for fast access. Steering wheel buttons can also operate some of the functions.

5.2 GENERATING CONCEPTS

After analyzing the competitors a *Function-Means Tree* was developed (see appendix D) from out of our Fishbone diagrams and the specification of user requirements, to use for generating concepts. The Function-Means Tree together with our specification of user requirements was then used in a design session which will be described in more detail below.

5.2.1 Design session

The design session was performed together with two persons from our reference group, experts in the areas of ergonomics and HMI.

Two rather different suggestions were sketched in this session; one based on clear awareness and quick access to the active safety systems, using text.

The other suggestion was based more on understanding, using an overview picture; changing depending on different driving contexts, system condition and road scenarios. Both suggestions were based on low visual distraction and therefore a high placement of the information to be presented.

The two suggestions did also differ from each other in choice of interaction and use; one was based on buttons (or a handle for more than four systems) placed to the right of the steering wheel, pull (or turn for the handle) to activate a system and to hold it in to be able to make personal adjustments, the other interaction was to be placed on the steering wheel to navigate a menu for personal adjustments.

A tutorial was suggested and discussed as an introduction for first time use and even suitable for the sales occasion. The tutorial should be a guide over all possible adjustments for each system, and thereby be appropriate for educating the driver. Important for those who are not used to handle a menu or do not know how to make adjustments, the placement of the tutorial, after first used, should be easy to get hold of.

The steering wheel interaction was discussed and evidently a development for the right side of the steering wheel with a thumbwheel, together with volume and track buttons, is suggested. This interaction possibility could then be able to be reversed and used on the left hand side for active safety systems.

These two suggestions were further developed, with respect to the specification of user requirements, and then paper prototyped.

5.3 FINAL CONCEPTS

Two suggestions was developed based on two completely different thoughts, the first suggestion (concept *awareness*) is to show a design developed for users without given any possibility for personal adjustments, satisfying users with low willingness to make personal adjustments. The other suggestion (concept *understanding*) is on the other hand to show a design developed with the possibility for personal adjustments, to be able to satisfy users with middle willingness to make personal adjustments, (even those with low willingness should be satisfied with this solution).

Troughout the following concept descriptions we refer to “the users”, which are the users, who participated in our study.

5.3.1 Concept Awareness

Awareness and quick access are the characteristics of this concept. The concept is developed to be most suited for a typical user as described in the user profile for Lowisa Morris.

USER PROFILE

Lowisa is created as a user profile, based on behaviour and usage patterns collected in our interviews and questionnaires.

Lowisa is 52 years old. She is responsible for administration and economy at a university. Lowisa and her husband drive a Volvo V40. Her relation to the car is just that is takes her from one place to another, and her overall trust in the car is very low. She uses mostly local communications to get to work. Sometimes when her husband does not use the car, she might use it to get to work.

Lowisa is not interested in technology whatsoever, does not read manuals and her knowledge in the area is poor.

Lowisa think it is important to use standardized information, so recognition is easy between different cars. The most important information should be presented in the flield of view and information which is not necessary for the moment should be visual, so you by yourself can decide when to take part of it. Lowisa does not like sounds, and if the sound from any system is too annoying she will turn the system off.

She likes interacting with buttons since it gives a feeling of control. She has never tried to use voice control: *"it feels new and strange"*. She doubts that it will work efficiently since noises must be filtered away, like talking to passengers for example. Lowisa thinks it is annoying and distracting to have to push buttons many times to get to the information wanted. She does not interact with systems during driving, since it means too much distraction, except from using pre-set radio channels.

Lowisa does not do any personal adjustments to the different systems in her car: *"the radio is set once and for all",* and would not like to change the adjustments because she does not think she is the right person to do it, due to her lack of knowledge.

She thinks there might be a need for active safety systems but she is afraid that she will trust the systems too much: *"I want to drive by myself"*. Since she has problems detecting vehicles in the blind spot, maybe BLIS would be a suitable system for her. She would appreciate the Semi-Automatic Parking in difficult situations in the city, but she is a bit doubtful about leaving the steering to the system. She is doubtful over using these systems because she doesn't know if she will react faster with this kind of systems then without. Lowisa thinks it is important that the systems are so good that they do not react on the wrong situations. In the future Lowisa thinks more and more systems will be introduced, and sees the importance of the car manufacturers deciding which systems should be working together at the same time.

She sees a danger in the car taking over to much, since the drivers always must have the outmost responsibility: *"systems should be able to help us, not rule us. Too many systems taking over functions may lead to more systems to keep us awake and alert"*.

INFORMATION PRESENTATION

The information presented to the driver is the information around the handle (placed on the left hand side of the steering wheel, on the dash board), which is the abbreviation of the system names; Lane Departure Warning (LDW), Blind Spot Information System (BLIS), Adaptive Cruise Control (ACC), Forward Collision Warning (FCW) and Semi-Automatic Parking (SAP), (see figure 18). A light belonging to each system is used to indicate activation and deactivation of the system (i.e. for activated systems a green indication light will show and for deactivated systems a red indication light will show).

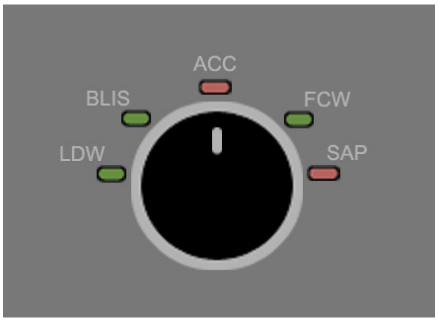

Figure 18: Concept Awareness.

INTERACTION AND USE

According to the users in our study an intuitive and learned interaction is important, which this concept is based on; turn the handle to be able to choose a system. Push the handle in to activate and deactivate the systems (see figure 18).

PERSONAL ADJUSTMENTS

This concept gives no possibility to make personal adjustments.

5.3.2 Concept Understanding

This concept is based on system understanding and control to increase the trust for the active safety systems, using an overview picture, changing depending on different driving contexts, system condition and road scenarios. The concept is developed to be most suited for a typical user as described in the user profile for Mark Middler.

USER PROFILE

Mark is created as a user profile, based on behaviour and usage patterns collected in our interviews and questionnaires.

Mark is 43 years old. He works as department manager within traffic safety. He and his wife drive a Volvo V50. He drives a lot both at work and during his spare time with his family. He also drives in different countries and thereby experiences different traffic cultures. Driving according to Mark is associated with: *"freedom and control"*. He highly trusts the car and is very interested in technology, and also has extensive knowledge in the area.

Mark prefers written information, since it does not "disappear" the same way as for example voice messages do, and there is a possibility to return to the written information. He likes graphical presentation and believes that: "*symbols should be used to present information in a simple way"*. Tactile information can be an option in quick and intuitive situations to get a quick understanding.

The information that is safety related should be presented in the field of view, but placed so that the focus on driving is not effected. He does not like information to be shown if it is not necessary for the specific situation.

Mark likes interacting with buttons the most but they cannot be too small, which is a problem in his car today. Even though he has had the car for more than a year, he cannot press a button without pressing the wrong one occationally. He thinks that the scroll wheel for volume also is an intuitive way to interact. He does not like touch screens since they do not give a feeling of control. The placement of the controls should preferably be around or on the steering wheel, since that does not mean that much distraction using them.

Because of Mark's interest in different systems he likes to explore the possible options there for different systems in the car. He would like the opportunity to do personal adjustments to the systems, since he drives a lot and it is especially necessary in different cultures to be able to adjust the systems to different traffic cultures. The adjustments are mostly done during driving but not in high demand situations, since it takes too much concentration. Mark thinks that the driver must have the opportunity to decide when adjustments are appropriate to do, since the outmost responsibility for safe driving is with the driver. He thinks that the memory function on the seats is practical, so that the personal adjustments automatically are suited for him and his wife.

He is convinced that active safety systems can prevent accidents, but they should not take over the control. He thinks that active safety systems are most fitting in motorway-driving and thinks that ACC and FCW could be useful. The Semi-Automatic Parking is not that necessary to him since: *"he knows how to park"*.

He is also doubtful to fully trust the Semi-Automatic Parking without being given information about distances to objects around the car, since he has a need for control.

In the future, Mark thinks it will be useful that the car prevents certain information when it is not appropriate to give the driver this information. Ahead, he thinks that more of our senses will be used for the driver to operate the car.

INFORMATION PRESENTATION

The information given is visual (in displays), since it according to the users is easy to understand and does not disappear. According to Galitz (2002) displayed objects are visible and provide a picture of the current context. Thereby the user initiates actions and feels in control, which increases user confidence and speeds up systems mastery.

According to Dewar (2001) the placement of displays should be such that they are readily seen by all drivers and not hidden by the steering wheel or stalks. Dewar (2001) state that it is preferable to locate displays high on the instrument panel in order to minimize the amount of time a drivers eyes must be off the road to read the display. The placements of our displays are right in front of the driver, as the users require it to be, to minimize the visual distraction (see figure 19).

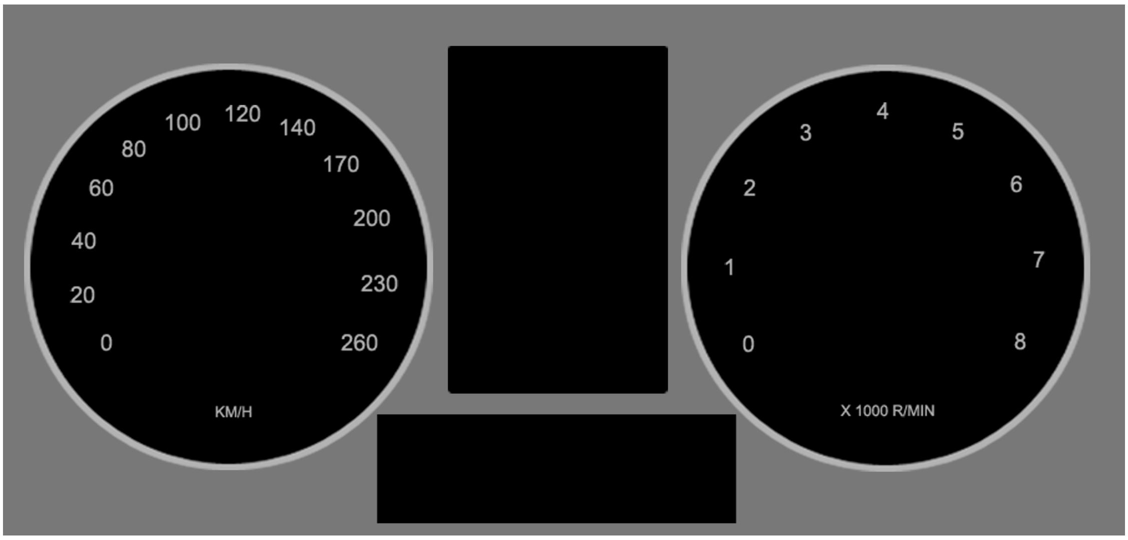

Figure 19: Placement of the two displays.

The users also required the information to be clearly presented, by grouping similar information to keep the information easy to discern and understand. The area for presenting the information is therefore divided in two different parts, one used for graphic presentations (the upper one) and one for text presentation and symbols (the lower one). This is to get a clear separation of the type of information in the two areas, since similar objects belong together, which is described by Monö (1997) as the similarity factor. The different areas will work together as a gestalt because of the proximity factor, the closer it is the clearer the gestalt, that is why the two parts works best together, but could work apart as well. The information is also presented with the symmetry factor; since the two displays are placed in the middle of the speedometer and tachometer.

Galitz (2002) states that graphics aid learning and are more entertaining, cleverer, and more appealing, which is important, especially for cautious and skeptical users. The colors we used for the presentation of the information is chosen to be similar to each other, in the same range of colors, considering the similarity factor, by Monö (1997) since it then looks like belonging together.

The users also required the information to give understanding, to increase the trust, by using standards and symbols. We therefore chose to use a standardized symbol language to increase the users understanding. ISO symbols 2575 were used as far as possible (see figure 20). Galitz (2002) state that, icons and symbols are easily learned and are more universal, and easier to comprehend, than text. Symbols can be recognized faster and more accurately than text and will more likely be understood regardless of language or culture. According to the experience factor, by Monö (1997) we observe conditions in the way we have learned from experience in order to recognize a specific gestalt, which makes it easier to understand information given from standardized symbols.

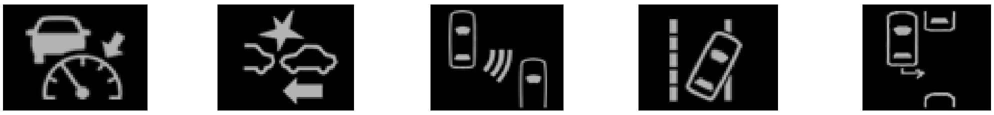

Figure 20: ISO symbols (from the left) for; ACC, FCW, BLIS and LDW and our own created symbol for SAP.

The concept will further be described using the scenario of motorway driving and inner-city driving to illustrate the design:

You are on your way back home to Gothenburg after attending a conference in Malmö. You drive on the E6, when your cell phone rings and you answer it quickly. Even though the road is almost straight you have some difficulties maintain the right position in your lane. At your help you have LDW which gives a sound warning when you are about to leave your lane.

As a complement to the sound warning, the situation will be graphically and textually described, as in figure 21.

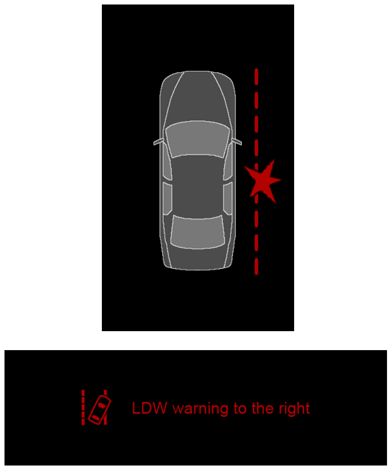

Figure 21: Complemented information given in the situation of LDW.

The traffic becomes denser and you need to adapt your speed to the vehicle in front, therefore you activate ACC that automatically will adapt your speed and the time gap to the vehicle in front.

The information given when ACC is turned on is, the time gap to the vehicle in front shown by the filled curves in front of the "head vehicle", and your set speed (see figure 22). This information will only be seen while you make your adjustments in the system.

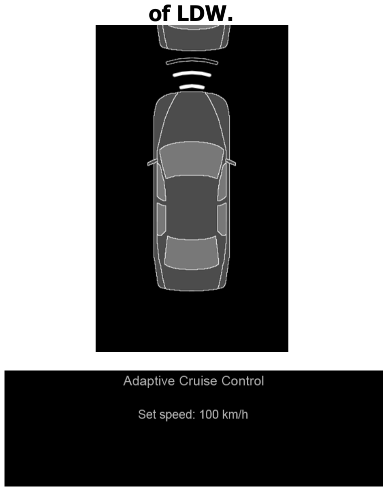

Figure 22: Information shown when activating ACC.

You continue to drive, when you suddenly notice that the car in front has made a strong braking. To avoid colliding with the car in front you have FCW to warn you with sound and light when you are about to collide.

As a complement to the light and sound warning, the situation will be graphically and textually described, as in figure 23.

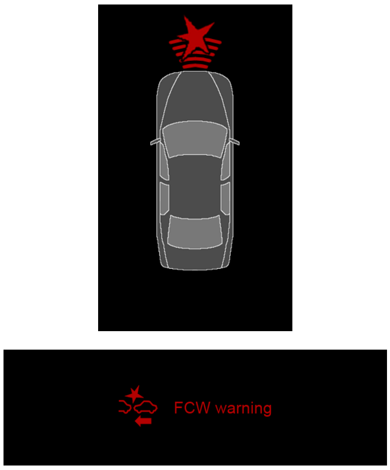

Figure 23: Complemented information given in the situation of FCW.

You take the exit from the E6 and approach Korsvägen. As you are about to change lane, BLIS observe a vehicle in the other lane. When BLIS notice a car in the blind spot, a light is given on the lower part of the rear-view.

As a complement to the light warning, the situation will be graphically and textually described, as in figure 24.

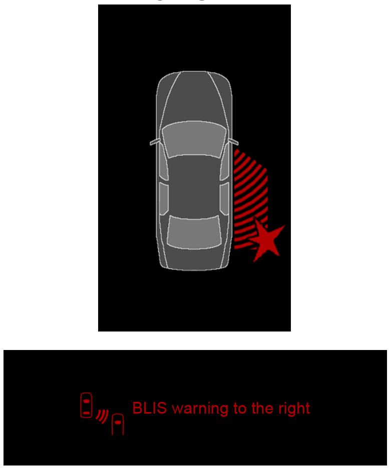

Figure 24: Complemented information given in the situation of BLIS warning.

When you drive through Korsvägen you start looking for a parking space, but it looks hard, the only available space is between a BMW and a Porsche. At your help in this situation you have semi-automatic parking, which help you park. The system check the available space, ask you to let go of the steering wheel, put in the reverse gear and give gas.

The information given in this situation is; a graphical representation over the situation, where the colored curves represents the varying distance in front, to the side and to the back, and instructions over when to do what (see figure 25).

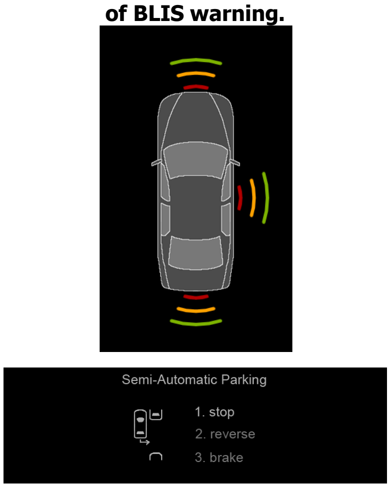

Figure 25: Information given when using Semi-Automatic Parking.

Dewar (2001) state that visual clutter within the vehicle increases the number of glances made by drivers, suggesting that panels should be designed with displays that are easy to see and unnecessary information should be avoided.

The users required the information to be presented when needed, and that the most relevant information based on situation should be presented, this is to be spared unnecessary or superfluous information and to be able to easier notice the important information. Considering the visual interference, to decrease the risk of information overload (Green, 1994), the information will only be shown in relevant situations; as long as everything is proper there is no need to present any information. If an error may occur it will be indicated, for example, as shown in figure 26.

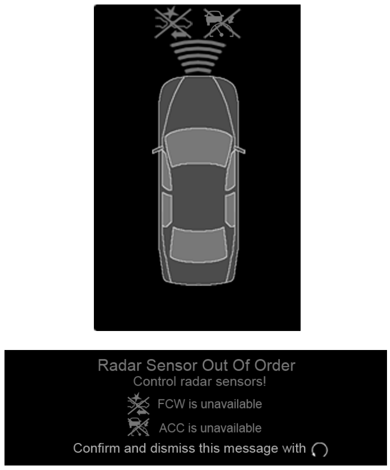

Figure 26: Information given when radar sensor is out of order, which will lead to unavailability for the two systems working with this sensor, (FCW and ACC).

Information that results in understanding is also about presenting how the systems work, which is done by giving the users information about why the system gives a warning. This is why we chose to give the complemented warnings (as shown in figure 21, figure 23 and figure 24). This complemented information is meant to remain after the warning situation to be able to give information about what is happening or has happened in a situation of system warning. Thereby the information will result in user understanding.

To make information understandable, it is according to the users, important to give consistent information, which we chose to work with for these complementing warnings. To signalize warning and risk for an accident we chose red color and a star. We tried to make the warnings as similar to the systems ISO symbol, which we thought was important for the understanding.

INTERACTION AND USE

The placement of controls should, as well as the placement of displays, be easily seen and reached, according to Dewar (2001). The requirement from the users was that the control should be placed easily reached, near the placement of the hands, which is the reason why we placed the control on the steering wheel (see figure 27).

The left side of the steering wheel will be used for interaction with the active safety systems, were a scroll wheel is placed among the existing buttons for ACC. Since ACC is a system that often will be used, dedicated buttons to operate this system is motivated.

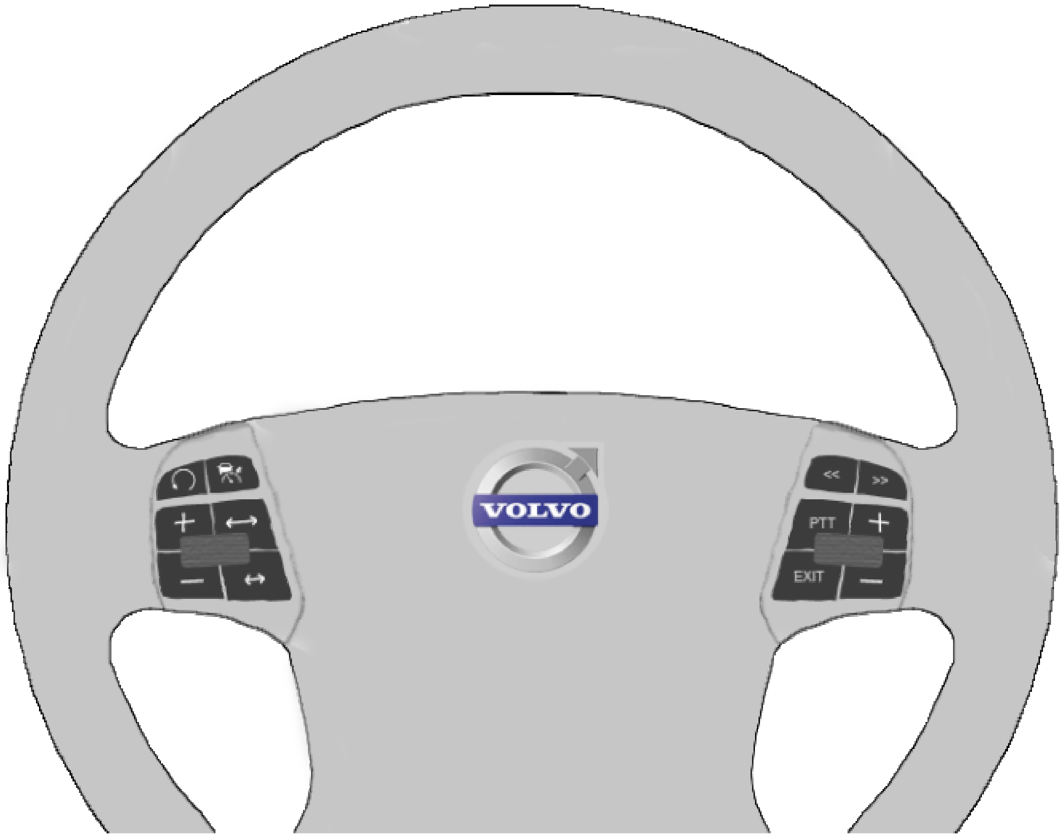

Figure 27: Interaction on steering wheel.

Other requirements from the users were that the control should be logic and have a clear shape, to be easily used and to minimize the distraction. Dewar (2001) state that designing controls according to the users' expectancies will reduce the need for decoding and mental processing will reduce errors and time to learn how to use them and will increase speed of control use and information gaining from displays. The control is therefore designed as a scroll wheel with a push function (see figure 27), mapped to the functionality of a computer mouse, which should make it a familiar way to interact.

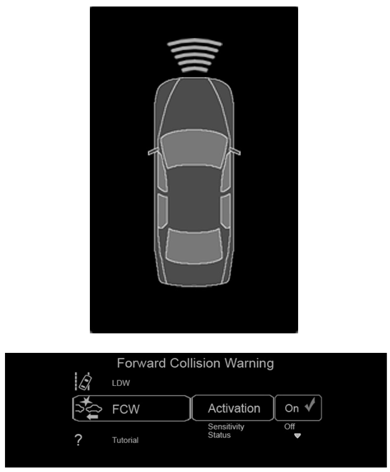

Figure 28: Activating FCW.

According to Dewar (2001) the perceived function influences how the control will be expected to operate, therefore one important consideration is control- display compatibility. That is, the control movement should correspond to its display, which is well thought about when designing the information controlled in the display. The feeling of scrolling a wheel is sought when developing the design of the menu. The marked choice in the menu is always in the middle, bigger than the other menu choices, to represent the highest point on a wheel (see figure 28). When scrolling the wheel the menu follows like the information was on a wheel. The user required the control to give feedback, which creates understanding and a feeling of control. This is why the scroll wheel has notches to help navigating without looking at the menu and to be able to learn which notch represents which system or choice in the menu.

The menu structure is also based on control, understandability and consistency. The symbol representing each system is shown together with the abbreviation of the system, the system name is written in top as the user move through the different systems. Arrows are chosen to indicate that more information is available, both on top and bottom of the current level of the menu (see figure 28).

In terms of personalization it is, according to Kramer et al. (2000), important that the interaction sequences help to point out what kind of state information that must be maintained, for example, the status of the user task, which is to know where you are in a menu structure. The menu structure is developed as a flat structure to be able, as a user, to know the placement in the structure. When on a marked system, the underlying choices are shown to minimize the possible mistakes (see figure 28).

The button with a curved arrow, used for ACC to activate and resume set speed (see figure 27) is used as a back button, when in the menu and to confirm an error message.

PERSONAL ADJUSTMENTS

According to the users in our study the information and interaction should be adjustable. The possibility to personally adjust the information or the interaction, gives the user a feeling of control. The way to reach the information about the systems may be done either by scrolling the wheel or by pressing the Push To Talk (PTT) button to the right on the steering wheel (see figure 27).

Since different user types have different information needs, the identification of multiple views will be needed, which is the basis of personalization, according to Kramer et al. (2000). Therefore the information is adjustable and will be described below.

Adjustment possibilities for the *safety systems* (LDW, FCW and BLIS) are; *Sensitivity* high or low and *Status* on or off. To adjust the systems sensitivity is for example in LDW to choose when to get the warning, depending on the distance to the road markings (sensitivity is as default set to high). Status on or off is the possibility to choose whether or not to have control over the different systems availability according to the systems functional limits (status is as default set to be off to not involuntarily increase the risk for information overload). Status of the systems gives understanding of the systems and at the same time a possibility to have control. To see that the system works as expected, the trust and understanding will increase. When status is chosen to be on a graphical illustration, as in figure 29, will continuously be shown, changing according to the system availability; if the status is chosen to be off, the upper display will remain empty. The status will probably not be necessary after long and continuously use, when the trust is build up.

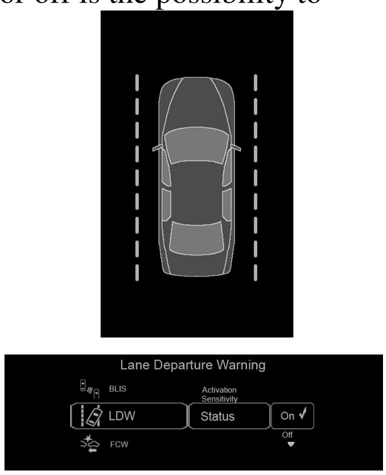

Figure 29: Status is chosen to be on for LDW.

There is another possibility to adjust the safety systems, by choosing to adjust all system together on the basis of road conditions; slippery or dry. By choosing one of these adjustments all safety systems adjust after these conditions. We chose to symbolize, the general settings with a spanner as used in for example cell phones to indicate settings (see figure 30).

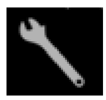

Figure 30: Symbol for general settings.

The adjustment possibility for the *Comfort systems* (ACC and Semi-Automatic Parking) is; *Detailed information* on or off. The detailed information is rather like the choice of *status* on for the safety systems, for example detailed information for ACC is information about set speed and the distance in meters to the vehicle in front (see figure 31), without *detailed information* on this information will just be seen for the driver when activating the system (detailed information is by default set to be off, to not involuntarily increase the risk for information overload).

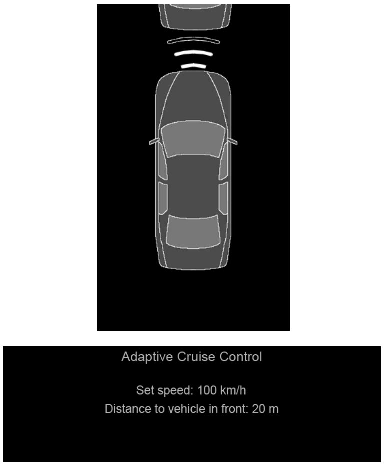

Figure 31: Detailed information ACC.

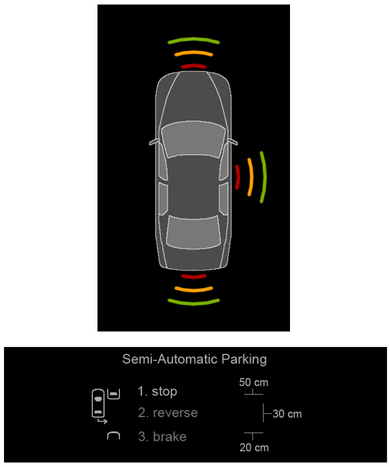

Figure 32: Detailed information Semi-Automatic Parking.

Through our study we have noticed a need for control, to have the possibility to control that the system is doing what is expected. Detailed information in Semi-Automatic Parking gives the user the possibility to control the situation in case of doubtful trust (see figure 32). Without the detailed information the user will only get the instructions about when to stop, reverse and brake. Detailed information is mostly suited for the novice users or for the particularly interested users – to get an increased understanding and control, or just interesting information.

Figure 33: Symbol for help function.

In terms of personalization it is, according to Kramer et al. (2000), also important to take population differences in consideration (for example technical knowledge, age, education etc), which can be done by providing personalization of help facilities. This was done by providing a possibility to get all information about the different systems; such as function and adjustment possibilities, symbolized as in figure 33. This help function is also meant to be a tutorial as a walkthrough the first time of use or as information and education at the sales occasion.

All personal adjustments will automatically be saved in a memory in the users' personal key.

5.4 EVALUATION OF DESIGN AGAINST REQUIREMENTS

As the last step in the concept development phase, the concepts should be tested, which were done in three steps; first an evaluation from design and usability principles, secondly an evaluation with the users and as last step a discussion of the concepts with the reference group to evaluate against organizational requirements.

5.4.1 Evaluation from design and usability principles

As the first evaluation we evaluated the prototype according to the design and usability principles by Norman (1988), Nielsen (1993) and Schneiderman and Pleisner (2005). The result from this part of the evaluation is presented below.

VISIBILITY

The visibility of the two concepts vary; in the concept *awareness*, the visibility is clear, and the users will likely be able to know what to do, in contrast for the concept *understanding* the functions are out of sight but with big flexibility possibilities.

FEEDBACK

Feedback is given both visual and tactile for both concepts. In concept *awareness* the handle gives visual feedback using red and green light indicating on and off for the systems, and tactile feedback through the notches on the handle responding to the different systems. In concept *understanding* the visual and tactile feedback are well connected, using mapping between the scroll wheel and display, both visual and tactile feedback are given.

CONSTRAINTS

One advantage of constraining is that it prevents the users from selecting incorrect options and thereby reduces the chance of making a mistake. Using constraints in concept *awareness* is well connected to visibility, since the options available are clear, the possibility of making mistakes is minimized. In concept *understanding* the menu structure is developed considering reducing possible mistakes by making the choices visible for the user and always showing where the user are in the menu structure.

MAPPING

The mapping between controls and effects are thought of for both concepts; for concept *understanding* the scroll wheel clearly map the effect on the display by using a feeling that the information is on a wheel, concept *awareness* clearly indicate the different system to choose around the handle and the maker on the handle maps the control to the effect of choosing the different systems.

CONSISTENCY

The importance of consistency is well thought of, since it contributes to the ease of using and learning. The consistency is especially thought of in concept *understanding* by; using diverse display areas for text and graphics, using symbols, using red color and a star in the complementing warnings to symbolize accident risk and using the similarity of the symbols in the illustrations for the complementing warnings. The consistency in concept *awareness* is simply used by having one abbreviation and one belonging light for each system.

AFFORDANCE

The affordance for both concepts is clear; to turn a handle and to scroll a wheel, the only thing that could be uncertain is the push function on both controls, which on the other hand should be quickly learned.

SIMPLE AND NATURAL DIALOGUE

To simplify and match the users' task in a natural way, we have in concept *awareness* used red light for off and green light for on, which is a common pattern. The use of standardized ISO symbols makes concept *understanding*, simple and natural.

SPEAK USERS' LANGUAGE

To base the terminology on the users' language are done in concept *understanding*, where the abbreviations of the system names are explained and ordinary words are used in the menu. Concept *awareness* on the other hand does not use the users' language, since it only uses abbreviations of the system names.

MINIMIZE USER MEMORY LOAD

The users' memory load in concept *understanding* is minimized by making the users' "road" in the menu visible, the complementing warnings are used for recognition and remembering. In contrast, the concept *awareness* does not minimize the user memory load, since the use of abbreviations, which is difficult to remember.

CLEARLY MARKED EXITS

To increase the users' feelings of being in control, the concept *understanding* offer an exit or back button as an easy way out of as many situations as possible, wich is easily learned. In concept *awareness* there are no clearly marked exits, and there is no need for it since the user will not get into situations in need of exits.

SHORTCUTS

To offer shortcuts for the experienced user to perform frequently used operations is solved by providing to use the Push To Talk (PTT) button, for concept *understanding*, to reach directly into each system or the help function. For concept *awareness* no shortcuts are available, and there is no need for it since all avaliable information is directly reached by the user.

GOOD ERROR MESSAGES

The rules for good error messages are followed in concept *understanding*; it is phrased in clear language, it is precise, it constructively helps the user solve the problem and it is polite and does not intimidate the user. In concept *awareness* there are no error messages at all. Such messages would be a sound message and since sound messages may be hard to interpret and does not remain we suggested not having any error messages for concept *awareness*.

PREVENT ERRORS

Better than having the good error messages is to avoid the error situation in the first place, which is done in both concepts. Concept *awareness* is clear and simple which makes it difficult to make mistakes. Concept *understanding* prevents errors by always providing information about were the user are and what could be done (in the menu structure).

HELP AND DOCUMENTATION

A help function is available for concept *understanding*, but not fully developed for the prototype. According to Nielsen (1993) it should be easy to search, focused on the users' task, list concrete steps to be carried out, and not be too large. There were no and will not be any help or documentation available for the concept *awareness*, since it was developed to be as intuitive and easily learned that a help documentation will not be needed.

CATER TO UNIVERSAL USABILITY

In concept *understanding* considerations for the needs for diverse users were taken into account, by offering personalization and thereby give the possibility to choose the amount of information presented for different systems and different situations.

No such considerations were taken into account in concept *awareness*, since this concept was developed for users without willingness to personally adjust the systems.

DESIGN DIALOGS TO YIELD CLOSURE

Informative feedback is given for both concepts; in concept *awareness* this feedback is given by a red or green light to indicate the completion of the actions turning and pushing, in concept *understanding* all actions are visible and feedback is given for all actions, most clear at the completion as a tick, to give the operators the satisfaction of accomplishment and to feel in control.

PERMIT EASY REVERSAL OF ACTIONS

To make actions reversible to relieve anxiety is one thing we have not made possible in any of the concepts. If the user has made a mistake, the action will have to be done again to make it right.

SUPPORT INTERNAL LOCUS OF CONTROL

Given the users the sense that they are in charge of the interface and that the interface responds to their actions is about supporting internal locus of control. This is done for both concepts; concept *awareness* fully support the feeling of control since the handle is totally driven by the user, concept *understanding* supports the internal locus of control by giving the personalization possibility, which gives the user a feeling of control when it comes to information and interaction.

5.4.2 Evaluation with the users

The other evaluation was done with the users, which gave us valuable knowledge about how they interpreted the information given and how well our design corresponded to their requirements. The user evaluation contained of; symbol understanding, discussion about error message, interaction (advantages and disadvantages), walkthrough for adjustment possibilities in the systems, discussion about the information presented for detailed information and a scenario walkthrough with belonging graphical illustrations. An inquiry of achievement of the user requirements, placement, form, function and colors were also discussed.

The prototype was discussed to see if the users' requirements were met through our solution.

SYMBOL UNDERSTANDING AND ERROR MESSAGE

The majority of the participants had the symbols for general settings (to be able to adjust all safety systems on the basis of road conditions) (see figure 30) and help or tutorial (see figure 33) wrong. The symbol we used for general settings, a spanner, gets interpreted the wrong way in this context. Nearly all of the users suggested that this was a symbol for when there is something wrong with the car and the need for a visit at a car repair shop. The help or tutorial symbol, as a question mark, was not easy to interpret either, maybe because the users are not used to this kind of function in the car, which makes it unfamiliar in the context.

We asked the participants to interpret the illustration of when the radar sensor is out of order (see figure 28). This turned out to be easily understood, everyone interpreted the information as that the systems were out of order, turned off or inactive.

INFORMATION PRESENTED

The participants agree that the information is presented when needed. One of the participants is a bit doubtful to the complementing warning illustrations; they may not draw to much attention.

The participants also agree that the information is prioritized and presented from its relevance for the situation. One of the participants thinks that the complementing warnings are most suited for the novice users, good in understanding.

One participant mentions that it is nice to know what cause the sound or light warnings; "*I quickly want to know what the problem is, so the information will have to be quickly interpreted."*

The information is clearly presented, it is quickly and easily understood and learned, according to the participants, but the text is a bit too small. One of the participants mentions that the complementing warnings are very similar, so something distinguishing may be needed.

The information gives understanding according to all participants, the graphical illustrations gives a lot. One participant add that it is also about what you know before, information attained from the salesman or instruction book. It could be difficult for someone driving a rented car, and then the explaining text is important, another participant adds. The participants agree that the concept *understanding* gives more understanding than the concept *awareness*, since;*"abbreviations can make you frustrated."* It is also good to get system understanding; that the complementing warnings remain a while to connect the system warning to the graphical illustration and which system it is about, one participant adds.

All participants agree that the information given is consistent, which is important to be able to understand. Graphical illustrations and icons are very good, "*short and simple is good"*, one participant adds. Another participant think that the consistent red star to indicate accident risk is good meanwhile one participant think that this indication is a bit to serious for BLIS and LDW, since it in traffic safety is interpreted as accident and collision.

"It is more appropriate in the situation of complementing warnings for FCW were the risk of an accident or collision is bigger."

(male, works with traffic safety)

INTERACTION AND USE

In terms of logic for the interaction, concerning intuitivity and form, the two concepts differ. All participants agree that the handle (concept *awareness*) was intuitive, logic and easy to interact with, but it would have been clearer if the symbols were used, since it is difficult to understand abbreviations. A few participants thought that the red and green indication may be changed to a neutral color and just use it as light or no light to indicate on or off, which is easier to discern for those with colorblindness. The interaction with the scroll wheel (concept *understanding*) was more difficult to understand how it works, not as logic as the handle. *"It could scare novice users"*, one participant adds. They thought it could be difficult with a scroll wheel with push function; it could also be difficult with precision, easy to by mistake touch other buttons. Another participant thinks it is understandable, but mentions that;

"I do not like scroll functions, but I think it is all about learning…"

(female, not interested in technology, age 50)

The handle felt more intuitive to the participants, but the scroll wheel was logic to a few participants as well, to those who were used to this kind of interaction. One participant mentioned that;

"A lot of people are used to the scroll function on computer mouse, therefore the mapping is good. It is important to develop things people are used to, because if you feel like you can trust it and feel comfortable, you will use it."

(male, technology interest, software developer, age 30)

There were also different thoughts about the placement of the interaction tool. A few participants thought it was a good thing that the handle (concept *awareness*) was placed on the left hand side from the steering wheel, to indicate that it should not be used during driving. A few participants thought it was not appropriate to place the scroll wheel (concept *understanding*) on the steering wheel because they should not be doing any adjustments and do not think it should be done while driving, and it therefore is unnecessary to place it there. Other participants thought it was more appropriate to have the interaction on the wheel, where it can easily be seen and reached.

As required by the users the interaction tool should give the user feedback, but considering the difficulties imagining something on paper, we chose not to evaluate this aspect.

PERSONALIZATION

Concerning the adjustability of the information and interaction, a few different opinions came up. A few of the participants thought there were good adjustment possibilities (the concept *understanding*), meanwhile others did not. One mentioned that it would be adjustable if you were able to enlarge the text size for example.

The participants thought it would be a good thing to have the possibility to make general settings to all systems on the basis of road conditions. But maybe this could be done automatically, since it is something that probably will not be changed from day to day.

SUMMARY

According to those users participating in the evaluation concept *awareness* is logical, easier to understand and to know were and what, easier to operate. The concept *understanding* is not as logical, but gives more system understanding and is appropriate if other systems will be added; it provides the opportunity to control the information given and makes it possible to personally adjust the systems.

- Only one of the participants preferred the scroll wheel and graphical illustration (concept *understanding*). This participant showed high values on trust, has deep knowledge in traffic and vehicle safety and is very interested in technology.This participant is used to BMW's iDrive and would like to have the possibility to make adjustments, but usually only does it one time.
- One participant prefer a combination of the handle (concept *awareness*) and the graphical illustration (part of concept *understanding*), this was a participant how did not want to have any adjustment possibilities, and do not make adjustments, doubtful about the placement and the push function for the scroll wheel.

- The remaining four participants preferred the handle (concept *awareness*), those participants differ some; a few of them trust that the systems are set correct from the manufacturer and consider themselves not to be the one to change that. One of them wishes to do as few adjustments as possible but because of big technology interest often try making adjustments but changes them back to default since trusting it is for the best. One of them do not do adjustments but would like to have the possibility, the other ones do as few adjustments as possible and are not interested in having the possibility to make adjustments.

  They prefer the handle since it is clear, easy and logical, but they see benefits in the scroll wheel and graphical illustration since it increases the system understanding and are better suited in flexibility/scalability issues, it also gives a possibility to affect things and then get control. A few of them think the scroll wheel seems difficult to use.

As we see it, the attitudes were in the first place about learning and habit when it comes to way of interaction. It was noticeable that technology interest, habit and age were related in attitude, as for example; one younger participant with high technology interest and habit saw the scroll wheel as very logical in difference with an older participant without technology interest and habit who thought that the scroll wheel was very difficult to understand and therefore were not interested in that solution. The attitude towards the two concepts were also connected to the willingness of doing adjustments; the one participant preferring the scroll wheel and graphical overview picture were also interested in having the opportunity doing personal adjustments while the other participants preferring the handle did not want to make adjustments.

5.4.3 Evaluation from organizational requirements

Discussing the design solutions with the reference group were done as the last step of evaluating the design solutions. Advantages and disadvantages were brought up with the two concepts.

The advantages with the handle (concept *awareness*), is that it is clear and easily foreseeable and is based on a familiar way of interaction. The advantages with the scroll wheel together with the graphical illustration (concept *understanding*) is that it gives good system understanding, the personalization possibilities gives adjustable information, and the interaction is easily reached on the steering wheel where the hands are supposed to be during driving.

The disadvantage with the handle is the flexibility/scalability, if more systems will be added it will no longer be clear and easy to foresee. Disadvantages with the scroll wheel are that the information is embedded and hard to find, and the interaction with the scroll wheel is not as familiar.

ALTERNATIVE SOLUTIONS

A few alternative solutions were discussed; the first one was to make the information clearer for the handle by using the system symbols together with the abbreviations, and change the colored lights to a neutral light to represent on and off (light =on, no light=off). Another solution might be to combine the handle and the graphical illustration, but then without any possibility to adjust the information presented.

Give the handle a few simple adjustment possibilities, by adding light indications to be able to give information about system status for example, this takes space and there are going to be a few different colors to indicate different stages, which may be difficult and limed for those users with color blindness. A button may be added to reach the adjustment possibilities for the handle, but a problem then arise, how to in a safe way interact and maneuver this information.

5.5 REFINE THE DESIGN

On the basis of our evaluations the concept *understanding* was the concept fulfilling the users as well as the organizational requirements to the greatest degree and therefore that was the concept to be refined. The most prominenet problems with our paper prototype are redesigned to fulfill the user and organizational needs.

INFORMATION PRESENTED

Figure 34: The two display areas.

The redesigned display areas are shown in figure 34. Throughout the prototype the text was done bigger, since this was something remarked by several of the participants. The graphical illustration of the car was made smaller to get more information in that display area and to make the information clearer. Another improvement done to make the information clearer was a line between every level in the menu.

Symbols

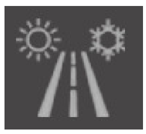

Figure 35: Symbol for Road Condition.

Since the majority of the participants had difficulties interpreting the symbols for general settings and tutorial or help, those were discussed. The general settings, were shown as a spanner, but is instead shown as in figure 35 to give the users an indication about what the general settings is for, namely road conditions. Therefore the redesigned symbol illustrates a road with a star and a sun to indicate slippery and dry road conditions. The name is changed to Road Condition. A choice to let these conditions be set automatically is added, but important is to make it possible for the driver to do these adjustments manually as well, to understand why the car acts in different ways depending on the road conditions.

We chose to reverse the symbol for BLIS (see figure 36), since most often in a situation when BLIS gives information to the driver, an obstacle is detected in the blind spot on the left side.

Figure 36: Redesigned symbol for BLIS.

To illustrate help, we could not come up with any suggestion, so the question mark (see figure 33) remains.

Complementing warnings

The complementing warnings were discussed, mainly considering the differences in serious of the information from each system. FCW is the system that is the most serious; the driver should probably not be warned by this system very often. LDW is less serious and will probably give warnings more often, be more active to the user, and give more information.

Different from these two systems is BLIS which is, told by the name, an information system which in this case means that this system also will be more active and give more and frequent information to the driver. Therefore the complemented information from BLIS will not be that relevant, since the driver quickly will relate BLIS "warning" to the lights in the rear mirror.

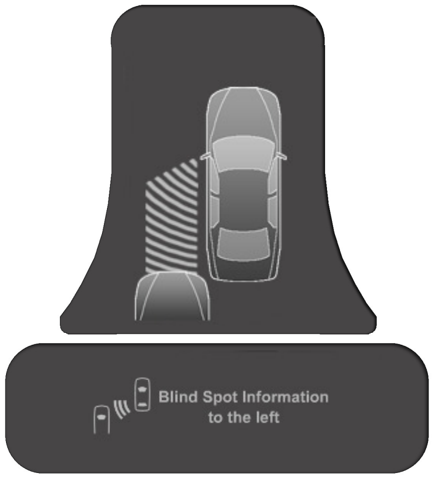

Figure 37: Complementing information for BLIS.

On the basis of the different systems' seriousness, we chose to change the information given for the different complementing warnings. The indication for BLIS was done more alike the ISO symbol, the red star to indicate risk for accident was removed.

The color on the text and radar marks was changed as well, to not mislead the drivers understanding of the situation (see figure 37). We kept the red color and the star for FCW since this is a clear accident risk, this warning were also done more alike the ISO symbol (see figure 38). We also choose to make the information given as complemented warning for LDW more alike the ISO symbol; to turn the car over the line marks to clearly indicate that the driver is in the wrong direction (see figure 39). The star will no longer be shown, since there is no serious risk for accident in this situation as in FCW. The line crossed by the car will be interpreted fast since it indicates that something is wrong.

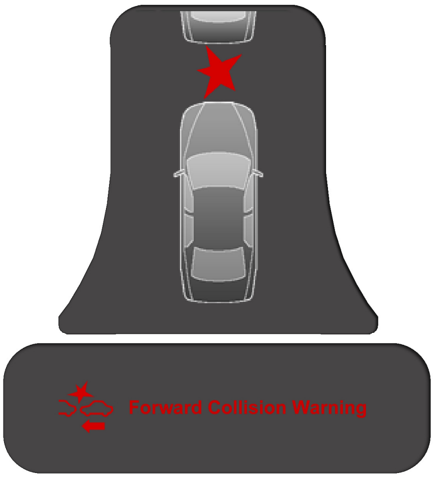

Figure 38: Complementing warning for FCW.

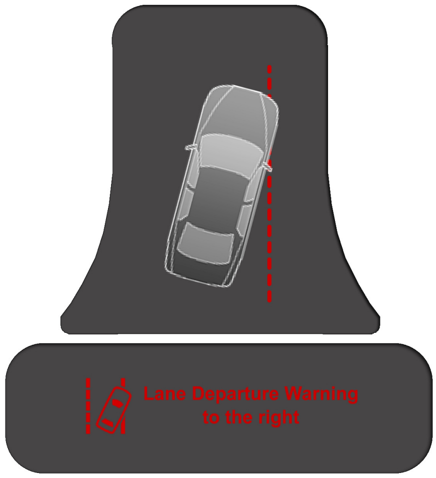

Figure 39: Complementing warning for LDW.

Considering the complementary information given about the different systems, there is also a difference in frequency of interaction; that is how often the driver will use something. If something is used often it is quickly learned. Systems like FCW and LDW will probably be used less frequently than BLIS, and the driver will probably be just as surprised every time the warning is given, considering inner-city driving and motorway driving.

In an educational point of view the complemented information from BLIS will be given maybe 20-30 times, before the driver will be considered educated on that system. After that the information can be given with predetermined cycles to repeat the education.

For the other systems, LDW and FCW, the information may be given more than 20-30 times before the driver is considered educated. The educations should be different for each key to the car, to separate different drivers' knowledge and driving experience.

Detailed information

The information given for ACC when detailed information is chosen was discussed, evidently information wanted in this situation is very market specific, some would like to know the seconds to the vehicle in front meanwhile others would like that information in meters. From a system educational point of view the information in seconds is more appropriate, since it is a constant factor (see figure 40). The number of meters would constantly be changing.

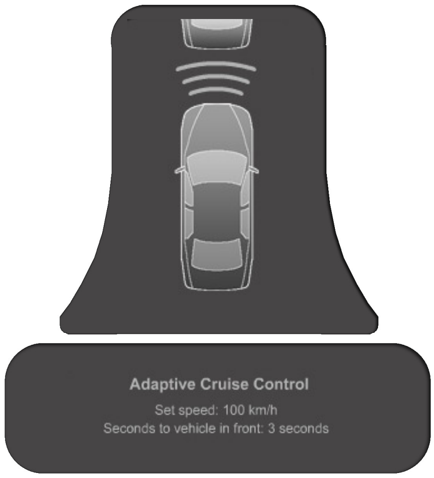

Figure 40: Detailed information given for ACC.

INTERACTION AND USE

To avoid the possible mistakes to get to other buttons while scrolling, separators are placed between the buttons, to prevent unwanted buttons to be pushed.

6 DISCUSSION

In this chapter we will reflect on, and discuss our methodology as well as the theoretical aspects concerning the areas of our work.

6.1 METHODOLOGY DISCUSSION

Choosing one method does always mean omitting others. Choosing a user-centered design approach was a natural choice for us to be able to meet our goal. An iterative process is a big part of the key to successful system development and the underlying principle in ISO 13407. Unfortunately, since the time was limited, only one iteration of the design solution was done.

Our working situation, with continuous contact, valuable input and feedback from the reference group, gave us good experience in working in a multidisciplinary team. We also gain valuable understanding of the different parts influencing the area of interest; vehicle safety, HMI, ergonomics, chassis and interaction design.

6.1.1 Understand and specify the context of use

As a first step towards a better understanding of the users in the context of use, was a literature study. The area of interest was broad and finding the relevant literature trough articles and books was time consuming, meaning that the literature study took longer than scheduled for. During the literature study a problem formulation was developed, along with the reference group, which was helpful to clear what parts actually were to be focused on.

The sources used were manly books and published articles from known researchers within our area of interest, which we therefore consider reliable sources. A few second hand sources unfortunately had to be used, because the sources of interest for various reasons could not be found.

UNDERSTAND THE ENVIRONMENT AND TECHNIQUE

To attain understanding about the environment and technique we did a test drive, which was very valuable; unfortunately, all safety systems in our study were not within this test car. Yet, we realized the function of the systems and saw how the interaction and information was presented, also among other systems in the car. Understanding about the technique was also achieved from the "one pagers", but even so it was difficult to understand how these systems influence the driver. This understanding would probably have meant much and would have been valuable to us.

UNDERSTAND THE USERS AND BECOMING USERS

To be able to gain understanding about the users we used a semi structured interview and a questionnaire.

Participants

The best of course had been to include drivers with experience of these systems, as were our goal for the qualitative selection of participants. But those active safety systems only come in the new generation of Volvo S80, meaning that our first aim was to get hold of Volvo S80 customers. In conversation with responsible persons at the Market Intelligence department at Volvo Cars, Torslanda, we agreed that we should find this experience within Volvo Cars to reduce the cost it would mean to find and use private persons.

Our new aim then became to obtain drivers of Volvo S80 company cars and drivers of QUIC-cars. Even this meant problems to us, since there were only two Volvo S80 company cars and the QUIC-cars where unfortunately not Volvo S80. Our next step was to find taxi companies and their drivers that hopefully have experience of theses kind of systems, since taxi cars often are well equipped. Neither this activity gave us any result. It was worth a try, but unfortunately we did not get hold of any experienced users, besides a few participants who had driven with BLIS for some weeks, which was a pleasant surprise.

In order to get the true problems and to get a better understanding for how the drivers respond and how their behaviour might change with this type of systems in the car, the best had been to get hold of experienced drivers. If we got ahold of experienced drivers we would have made observations to in an efficient way receive understanding of the users' behaviour in the context of driving, since we think that would have given us more valuable information and thereby understanding.

It was favorable to use participants both within and outside Volvo Cars. Valuable information and understanding were gained from the QUIC-car drivers, since they have a great experience in driving and are used with numerous different systems in the car and were able to articulate their present problems and future demands. It was also favorable to have both younger and older participants within the study in order to look on differences and similarities concerning age, and not only to use the typical Volvo consumer. The distribution between men and women was positive, but it had been better if we could have gotten ahold of an even division between the sexes. 20 interviewees were a sufficient number, to have more had probably not given us more information since we noticed that we reached a saturation point. Tailored after our resources more than 20 interviewees would have taken far too much time both for collection the data and the analysis of it.

Interview

The choice of using a semi structured interview was suitable for our study, since the interviewees differed a lot from each other and we were able to adjust the interview to be fitted after knowledge and experience by each interviewee. This is of great importance, according to Bell (2000), and we learned to see the value of it.

We spend a lot of time to get a good basis for the interviews, which we afterwards are glad we did. The questions were discussed with the reference group as well as our examiner to see to that relevant questions were asked and that no important questions were left out. This meant that; the questions were well formulated, we knew what we would like to get answered and why, which led to that all information attained was relevant and we knew what to do with the gathered information afterwards. We did not feel that we missed to ask things we would have needed answers to.

Conduction the scenario for the interviews was also done with a lot of help from the reference group, to get the function and purpose with the systems right, since our understanding about the technical part were not so good at that point. A pilot study was done to test the interview set-up with; the interview questions, scenario and questionnaire. This was also done to be able to get an idea of the time for each interview. Despite our pilot interview the time calculated for each interview was sometimes not enough, some of the interviewees were very verbal and thereby exceeded the estimated time without problem meanwhile others did not make use of their time.

The time scheduled for the interviews were also exceeded, since we chose to let all interviewees decide the day and time and it was therefore difficult to get an efficient interview schedule. All interviewees were let to answer the questionnaire a head of the interview to save time at the time of the interviews, since we thought it would be easier to get hold of the information this way than giving them the questionnaire afterwards and then gather all information.

We are satisfied with they way we divided the interviews amongst ourselves, meaning that we always were responsible for the same part of the interview, to decrease the possible bias that may occur due to different pronunciations. This also lead to that we quickly learned our part of the interview which were an advantage since we then easier could use probing to get the most out of each interview. Interview techniques are extensive, there are a lot to learn, which would have been valuable knowledge to gain in advance, but since the time was limited it was not prioritized. During each interview we made notes and used sound recording to have as backup. This backup was helpful since it a few times was hard to follow making notes. The use of representation as a verbal scenario and posters we noticed were supportive for the interviewees for understanding and inspiration. Other stimuli were discussed, such as using Volvos' driving simulator at Universeum, in Gothenburg, to get a more realistic context for the interviews. The disadvantage with the simulator as stimuli was the untidy, rather narrow and noisy environment, which made it inappropriate to use. Using advertise videos to represent and explain the active safety systems were also discussed, but neglected since it would be too time consuming to use and all systems were not available on video.

Questionnaire

The questionnaire used consisted of validated methods in order to ensure relevant data, some modifications was done however, in order to be able to measure what we were interested in and not get unnecessary information. A questionnaire should, according to Patel and Davidsson (1994) be varying so the interviewee holds up the motivation and avoids to get stuck in an answer pattern. Unfortunately this was something we could not influence, since the methods we used where validated methods, and if we would have changed them too much, the reliability of the information gained would not have been ensured.

Using the Ten-Item Personal Inventory (TIPI) was complicated, some of the interviewees pointed out that it was difficult to complete, it was also difficult to interpret and draw conclusions from since the answers sometimes did not mean anything. The alternative had been The Big Five with 240 questions, which were not relevant considering our time limits.

A few interviewees commented a bit indignant about how the questions was put and had problems to answer them. According to a few interviewees emotions vary a lot from situation to situation, which made it hard to do a proper and general judgment over feelings while driving. We do not know how much mind and time spent to answer these questionnaires, but we got all replies and we think we attained interestingly and applicable information out of them.

Meeting many different individuals meant much and it got us more interested in what cause those differences.

6.1.2 Specify user and organizational requirements

The gathered information from the users was interpreted and analyzed to be able to specify user requirements. As Patel and Davidsson (1994) state, this process was probably marked by us interpreting it. Since every developer and designer interprets information differently, owing to different backgrounds, educations and experiences. Therefore the results, which will be the base for the remaining work probably would differ to if someone else had done it.

USER REQUIREMENTS

To be able to specify the user requirements, Fishbone diagrams were used over the three areas of interest; awareness and overview, interaction and use, and personalization and individual adjustments. Using these Fishbone diagrams was a good way to get a clear overview over which factors that create the problem and the collected information within the different areas, see its contexts and thereby interpret the information. On the basis of these Fishbone diagrams, we could thus develop a specification of user requirements.

ORGANIZATIONAL REQUIREMENTS

The organizational requirements were continuously built up meanwhile our problem description was developed with the reference group. The requirements were thereby related to the different areas involved in our work; safety, HMI, ergonomics, interaction design and chassis.

Most requirements were gathered from the ergonomics department considering form and location of controls and sizes of text and symbols (ISO 2575), also concerning placement of displays and the contrast on the screens. This was of course requirements taken into account but not exactly followed since these kinds of requirements often are taken into account when the final design solution is put into manufacture.

More overall requirements concerning law and for instance from the marketing department was not taken into account since we with our time restriction unfortunately not could take considerations to all areas influencing a new design solution. The marketing department wants it to be “visible to the neighbors”; since it should be shown that the car has plenty of systems. This was something we intended to take into account in the beginning but decided not to since we could not limit our proposal there after.

6.1.3 Produce design solutions

After identifying user requirements competitors’ products were analyzed, which were done by choosing a few competitors we knew were geographically close to each other to be able to visit as many as possible, as efficient as possible, since our time was limited.

At the visits we contacted a few vendors to get information about their active safety systems, the interaction and information presented and even insight about their customers’ attitude concerning these aspects. We maybe should have been more persistent to get information from their customers since this could have given us valuable information to use. We could also have made more visits to get more out of this part of the process, because in a few places we could not get hold of the right person to talk to, or the right car model was not available.

As the next step producing design olutions, a Function-Means Tree was used, as suggested from one person in our reference group. From out of this tree and the specification of user requirements there were possibilities to generate a lot of different concepts. Unfortunately this was not fully taken advantage of, it was used in a design session were only two from the reference group were able to participate. After this workshop we could have used this material by our selves to generate more concepts, but since we already had an idea over a final concept and such an idea were developed at this time it was difficult to "kill our darling" and generate more concepts.

The users were not participating in the part of producing design solutions, which would have been valuable, but again the time was limited and it would have taken much time both for us and for the users to participate in this part of the process as well.

6.1.4 Evaluate design against requirements

One evaluation plan was done where the; objective with the evaluation, choices of participants and the task set-up was cleared. This led to that we both had the same objective to follow; we knew why the tests were done, which was a good starting point. Our supervisor controlled this plan in order to ensure its quality.

The first evaluation we carried out, on the basis of the design principles of Norman (1988), Nielsen (1993) and Schneiderman and Pleisner (2005), gave us a clear picture over advantages and disadvantages with our design proposals. This evaluation could have been done with more experts than ourselves in order to look at our design from other points of view. To evaluate your own design, might contribute to that some things are missed that others might have thought about. It is a risk that the evaluation criteria's are interpreted on the basis of the design and not the other way.

The second evaluation was carried out with a few of the interviewees. Even at this stage a pilot study was made to check the set-up and to see that everything was understandable. This was very valuable, since we could control the time consumption and the order of the different parts in the evaluation.

The third evaluation was carried out with the reference group, to see how well the design solution met with the organizational requirements. We thought about evaluating the design with the reference group before the evaluations was done with the users, but since the time was limited we felt it would be difficult to have time for that before the user evaluations.

PARTICIPANTS

To use participants who had already participated in the interview had clear advantages, as we see it, we knew them o they knew us, which made the dialogue between us good. Another advantage was also that they had an insight into the different systems (even though they did not completely remember it all without our help), which meant that the design solution was easier to provide. To use the same participants were also an advantage in order to later link their properties and comments to the results we gathered from the interview. This also meant that our understanding (or perhaps in some cases confusion) for the users increased, the understanding about there differences and that the requirements are difficultly caught and interpreted.

It is crucial to understand the users to be able to design for them. According to Norman (1986) the user is creating its own model of the product and that model is almost never the same as the design model.

Good user understanding makes it easier to develop a design model that is in similarity with the model the users are creating. To understand the users are often difficult, which makes it complicated designing for them. In our study we could see that some of the interviewees changed their opinion between the interview and the user evaluation, which is interesting. Why the interviewees changed their mind between the interview and the concept evaluation might depend on difficulties to explain their needs. Several of the participants mentioned that it is difficult to evaluate something on paper; *"it is difficult to imagine how it would work for real."*

According to Norman (1988) behavioural design should be human centred. It is all about understanding and satisfying users' needs. Users' needs should be taken into account when designing with a user-centred perspective, but is the user always right? The designer should as long as it is possible listen to the user, but probably there will be situations were the designer need to do what is right through verified theories. Not only different personalities can be a limitation when designing for the users but also different generations might become a problem.

Our choice of having participants in the same age range that we had during the interviews also felt important in order to get attitudes from both younger and older and also to see if there were differences in attitude and views that was based on age.

To only use the reference group in the evaluation against the organizational requirements, was maybe a risky choice, since two persons from the reference group attained at the design session were the two original design suggestions were created. This aspect may have affected the evaluation.

6.1.5 Refine the design

On the basis of the results from the evaluation the information was discussed and interpreted, to be converted and developed to an interactive prototype in Macromedia Flash. Since our time was limited, there were unfortunately no time to follow-up the work of the interactive prototype with an evaluation of the refined design solution.

6.2 GENERAL DISCUSSION

What are the future demands of designing HMIs, and what affects the driver in the driving context? These are questions that need to be discussed, to be able to design a solution that works for safe driving.

TECHNOLOGY UNDERSTANDING

The change of generations that we are experiencing now makes a big gulf between the old generation and the younger generation. The younger generation are born and raised with computers and often has another view on the new society than the old generation does. In our study we could see a great example of this when we discussed different ways of interaction. The scroll wheel that we chose as interaction tool one of our interviewee from the younger generation directly saw the connection to the interaction with a computer mouse and thought it was very intuitive. A man from the older generation, on the other hand, did not like the scroll wheel and mentioned that scroll wheels should not be used in cars. It probably has to do with his personal opinion but also his experiences. He did not see the connection to the computer mouse. The same male preferred the old-fashioned way with buttons. This might show on differences between the two generations. To be able to design a product that fits as many consumers as possible, personalization might be the answer.

PERSONALIZATION

According to Gehm (2005) it is the users that decide if a product will be successful or not, meaning that the users' demands must be met with carefulness. The users expect more of future products, and cars are not an exception. According to Cooper and Reimann (2003) people like to change things around to suit themselves. Personalization of products we use everyday will become more important in the future. The personalization is on its rampage and the users will want their products to be adjustable. Maybe we are on the way to fully adjustable products. The willingness to be able to personalize will probably mean relatively more expensive products, at least in the beginning. Are the users really ready to pay that extra money to have their products even more adjustable?

There might also be another view of personalization. According to our study, interviewees mentioned that they do not think they are the right persons for doing settings in the future active safety systems. They think that this should be done from the manufacturer, and people might not think they have the right knowledge to do personal adjustments to a safety system and that is still should be safe. Well, this is quite interesting. We think that a system that should provide safety to driving should probably not be able to be set by the driver, although, to give the user the possibility to personalize the product it uses might give the user an increased feeling of control and pleasure.

CONTROL

Our study shows that the driver do want to feel in control, to some extent. A few interviewees did not want the Adaptive Cruise Control system, thus they would no longer feel active during driving. According to Dewar (2001), systems that are too automated will reduce the drivers' attention and gradually loose the ability to control the car when an emergency occur and the driver need to overrule the system. Maybe the reason why the interviewees did not want the Adaptive Cruise Control System might depend on the feeling of control. We think that loosing control or no longer being active in driving might end up in increased workload or underload. According to De Waard (1996) new systems or devices often increases the driver workload but they might also have the opposite effect of driver workload (e.g. underload).

WORKLOAD

According to De Waard (1996) future cars will be filled with high technology in-vehicle devices. They will all increase driver mental workload and possibly affect behaviour negatively, and will therefore be a threat to traffic safety. Implementing more technology often is connected closely with more information to the driver environment. This might result in a more complex and cluttered driver environment. More available information to the driver might affect people that are more prone to distraction, according to Dewar (2001). If the driver cannot keep the eyes away from the presented information while driving, the information becomes a distraction to the driver. To decrease workload from different in-vehicle systems, transparency might be a possible solution.

TRANSPARENCY AND TRUST

The transparency of a system deals with questions about how much information the systems should be presenting. Maybe the system should work in the background without the users' knowledge, often referred to as ubiquitous computing.

We think that active safety systems should be implemented in a way that the driver do not need to be aware of the system until it is necessary. If too much information is given from the system the users might trust the system too much, which might lead to adaptation and the user might not go in to overrule the system when necessary. Trust might also be a problem with systems that do not perform as the user expects it to do. It can be a problem to discover obstacles in the blind spot, maybe especially in messy city-traffic situations. VCC is leading in safety and offering their Blind Spot Information System to the customers but according to some of the interviewees the system is not really mature. The problem is that the system flashes too much, above all in city traffic. The frequently flashing information would be, according to the interviewees, disturbing and will probably lead to deactivation of the system. The information might not be of interest until the driver decided to change lane or does a big steering wheel movement. So the information given from the system can be seen as superfluous.

This can in the worst case, mean that the user does no longer trust the system. Muir and Moray (1996) states that trust in system often is big in the beginning. They also state that trust in a system might change during experience with the system and when the preformance drops below a certain point of what the user expects the system to do. The problem with increasing trust and adaption to systems might be decreased if the systems functionality is not that clear. How much information should be given to the user? Maybe safety systems should be handled differently from other systems because it is about giving the user a safe driving environment. Maybe these systems should be smart enough to adjust automatically.

SMART TECHNOLOGY

From our interviews many of the interviewees mentioned that active safety systems should be automatically set, adapted by the environment, situation, and other vehicles. This is in many matters probably possible with the technology today, but is this what the users really wants? Do the users really want a smart car that does all the settings? Shouldn't the car take too much of the control and the driver would loose their feeling of control? Some consumers would certainly not want a car like that, while others probably would. There are many functions that could be smart without the drivers noticing. To only give the driver the information that is needed is something that VCC already has, through their system Intelligent Driver Information system (IDIS). If the system calculations say that the driver is not able to take in more information at that time, the system will hold certain information. We will certainly be seeing more of these kinds of systems in the future. So how can we in the future, design systems that do not contribute to increased distraction and will end up in increased workload or underload?

VEHICLE DESIGN

Driver workload can be affected by how the vehicle is designed, according to Dewar (2001). So we need to carefully design our future vehicles. Increased amount of in-vehicle system does affect the amount of information presented. Much of the information might be superfluous or not presented in the right situation. This could be seen in our study, were many of the interviews considered the tachometer as superfluous information. The tachometer is probably still there because of its origin. The combined instrument has since decades back had two meters. This has become a design language and too remove one meter would probably affect the balance in the design. Maybe VCC is about to change.

The newly presented concept car, the Volvo XC60 has only one meter, a speedometer. Unfortunately concept cars are not known to be introduced to the market as they first were presented, but maybe soon, we can see a production car from Volvo with only one meter?

WARNING DESIGN

Not only is the design of the vehicle important. In our study we found a discussion concerning different warning types and how different people do think about them. It seems that different warning types affect people in different ways.

Sound as warning type, was not preffered by a few of the interviewees as they got scared of the sound. Tactile warning types, such as steering wheel and seat vibrations are other ways to make the driver react and act. Even this kind of warning type was questioned by the interviewees; they mentioned that a vibration could make them think that the car was broken. Maybe this is some of the explanation behind warning types, especially when it comes to active safety systems, these systems are developed for increased safety and maybe to “scare” the driver do make the driver react fast and intuitively. Probably the design of warning types is carefully designed to work as they do. Maybe these different warning types are not for the drivers to like but to react to. So how should the automotive manufacturers design their warning types? There is probably a need for further studies concerning different warning types and how different drivers do react to them.

7 CONCLUSION AND RECOMMENDATIONS FOR FURTHER RESEARCH

In this chapter we will discuss the conclusions of our work and present a few topics as recommendations for further research.

7.1 CONCLUSION

To create a HMI solution to make the driver more aware of the car's active safety systems a clear overview with consistent information is important for understanding. Understanding is attained by presenting the most important information to the driver; by information suited for the current situation and not foisting the driver with superfluous information.

An intuitive way for the driver to interact with the HMI should be based on clear affordance, give informative feedback and should not contribute to increased distraction. Judgment about intuitive interactions is individual; depending on variables such as, experience and interest of technology. Interest of technology as well as trust is aspects influencing the drivers' relation to active safety systems, as well as their willingness in making personal adjustments. The possibility of personalizing the systems is required by more demanding drivers to satisfy their need of feeling in control.

Designing a flexible HMI solution that is not restricted to a specific car model or a permanent number of active safety systems implemented, could be reached by developing a computer-based driver-vehicle interface. By using computerized technology the information presented can easily be exchanged and used for communicating other information to the driver.

7.2 RECOMMENDATIONS FOR FURTHER RESEARCH

Groeger and Rothengatter (1998) state that the key to design for drivers is the understanding about road users' behaviour, and the most challenging task is to take the drivers capabilities into account as well as individual and momentary differences in these capabilities. Further research is needed to know how to understand road users' behaviour. This thesis gives results on a few aspects concerning user behaviour, their relations to the systems in the car and what affects them in the context of driving, but more research among these aspects is needed, individuals change with time as well as technologies evolve, thereby the drivers' relation to the car and the systems within changes as well.

One of the main issues concerning the design of HMI for active safety systems is also to understand the behavioural adaptation effects there might be when these kinds of systems is implemented. The range of active safety systems on the market today is limited which made it difficult for us to get the understanding about how these kinds of systems effect the drivers. Therefore we would be interested in further research concerning this.

To follow the research we have been able to be a part of, towards developing a safe and usable design for active safety systems would certainly be interesting for us. This area is of great importance for VCC so the reaserach will continue.

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APPENDIX

APPENDIX A: SEMI STRUCTURED INTERVIEW

Introduktion

Vi vill börja med att tacka för att du tog dig tid att medverka i denna intervju. Vi är alltså studenter från magisterprogrammet Människa Dator Interaktion - Interaktionsdesign på IT-Universitetet i Göteborg som tillsammans med Volvo gör vårt examensarbete. Syftet med vårt examensarbete är att ta fram en enkel och enhetlig lösning för interaktionen med bilens olika aktiva säkerhetssystem. Dessa aktiva säkerhetssystem är system som ska förhindra olyckor.

Intervjun innefattar tre delar:

- □ En enkät som du har fått möjlighet att fylla i inför detta intervjutillfälle, har du inte gjort det finns det tid för dig att göra det efter intervjun.
- □ Ett scenario där vi kommer att beskriva olika situationer som kan uppstå i trafiken. I samband med dessa situationer kommer också ett antal frågor relaterade till situationerna att ställas.
- □ En djupintervju där frågor kommer att ställas inom olika områden relaterade till de aktiva säkerhetssystemen och bilens övriga system.

Personligt

1. Namn, Kön, Ålder, E-post

   Berätta lite om dig själv, utbildning, jobb osv.

   Vilken bilmodell kör du idag, vilka system finns i den?

   Har du några aktiva säkerhetssystem i din bil? Vilka?

   Har du kört någon bil med aktiva säkerhetssystem någon gång?

Scenario

I följande scenario kommer vi använda ordet inställning. En inställning är något som förändrar systemets beteende, exempelvis att ställa in radion så den ger dig trafikinformation eller ställa in känsligheten i olika system, inställningar i navigatorn så som att ändra storleksförhållande på kartan eller val av information som ska visas, ex. bensinstationer, kyrkor.

Det är torsdag eftermiddag, klockan är 16:09. Lite trött och allmänt sliten sätter du dig i din bil. Du ska ta åka hem från Malmö till Göteborg efter ett par dagars konferens. Efter en stunds jobbig innerstadskörning kommer du till slut ut på motorvägen, E6:an som skall ta dig hela vägen till Göteborg. Du är inte ensam på vägen denna torsdagseftermiddag, det är mycket trafik och ett högt tempo men trots detta sjunker du snart ned i en behaglig position. Din mobiltelefon ringer och du svarar snabbt. Det är din arbetskamrat Lars på Research and Development på Volvo, Torslanda. Han undrar om du vill följa med och ta en bit mat vid 19:30 tiden, du svarar att du är på väg hem från Malmö men tror att du skall hinna. Trots att vägen är näst intill rak så har du lite svårt att koncentrera dig och hålla dig i rätt position i filen då finns funktionen Lane Departure Warning (LDW) till din hjälp. När du är på väg att långsamt lämna din fil ger LDW ifrån sig en ljudvarning.

2. Vad för information skulle du vilja ha presenterad från detta system och var?

3. Vilka inställningsmöjligheter skulle du vilja ha för att anpassa systemet efter dig?

Trafiken tätnar och tempot går ner en aning. Eftersom hastigheten gått ner och du hela tiden behöver anpassa hastigheten till bilen framför slår du på Adaptive Cruise Control (ACC). ACC fungerar på så sätt att du som förare ställer in en lämplig hastighet och ett tidsavstånd till bilen framför, sedan anpassar ACC hastigheten och tidsintervallet till bilen framför.

4. Vad för information skulle du vilja ha presenterad från detta system och var?
5. Vilka inställningsmöjligheter skulle du vilja ha för att anpassa systemet efter dig?

Du känner dig säker och trygg, allra minst tror du att en olycka skulle kunna inträffa. Men plötsligt märker du att bilen framför dig har gjort en kraftig inbromsning för att undvika ett trasigt lastbilsdäck mitt i vägen. För att undvika att du kör in den framförvarande bilen finns Collision Warning (CW) till din hjälp. CW är ett system som varnar dig med ljud och ljus då du är på väg att kollidera.

6. Vad för information skulle du vilja ha presenterad från detta system och var?
7. Vilka inställningsmöjligheter skulle du vilja ha för att anpassa systemet efter dig?

Du kör av motorvägen och trafiken är fortfarande tätt. När du närmar dig korsvägen vet du att du måste byta fil och när du precis skall göra ditt filbyte uppmärksammar Blind Spot Information System (BLIS) en bil i den andra filen. BLIS hjälper dig som förare att se bilar eller hinder i dödavinkeln. Upptäcker BLIS en bil i dödavinkeln ges en ljusvarning på nedre delen av backspegeln.

8. Vad för information skulle du vilja ha presenterad från detta system och var?

Trots att korsvägen är rörig, med många olika trafikanter att lägga uppmärksamheten på, tar du dig helskinnad igenom. När du närmar dig restaurangen där du skall träffa din arbetskamrat uppmärksammar du att det ser svårt ut att hitta en parkeringsplats. Den enda tomma parkering är mellan en Porsche och en BMW. Inte direkt bilar man vill backa in i. Till din hjälp har du Semi-Automatic Parking som är ett system som med halvautomatik kan hjälpa dig att parkera. Systemet kontrollerar den tänka parkeringsfickan och räknar ut om bilen kan parkeras på den tänkta platsen. Systemet ber dig släppa ratten och lägga i backen och gasa, systemet sköter styrningen.

9. Vad för information skulle du vilja ha presenterad från detta system och var?

Informationspresentation

Som inleds med några frågor om informationen som finns tillgänglig i bilen. Och vi undrar…

10. vilken typ av informationspresentation du föredrar? Varför?

    Hjälp till med exempel om det behövs: visuell (ex. display), audionom (ex. röstinformation), taktil (ex. information genom känsel/vidröring))? Varför?

11. Var tycker du informationen ska presenteras för att den ska vara lätt att ta till sig och lätt att hantera? Varför?
12. Vilken typ av information tycker du bör vara tillgänglig under körning? I vilka situationer är informationen speciellt viktig? Varför?
13. Tycker du informationen från något system stör dig under körning? På vilket sätt?

28. Tycker du att du har den information du önskar om systemen? Finns det situationer då du saknar viss information? Finns det situationer då du tycker viss information är överflödig?

Interaktion

Vi går nu över till frågor riktade mot interaktionen eller hanteringen av olika system i bilen och undrar om det…

14. är lätt att använda och förstå hur du ska använda de olika systemen i din bil? Varför/varför inte? (Ge ett exempel på ett system som är lätt att använda.)
15. Finns det något system som du tycker är svårt att använda? Vilket/vilka? På vilket sätt?
16. På vilket sätt interagerar du helst med systemen? Varför?

    Hjälp till med exempel om det behövs: röststyrning, touchscreen, knapptryckning, vred, joystick… Varför?

17. Känns hanteringen/interaktionen med systemen logisk? Varför/varför inte? (Ge ett exempel på ett sådant system.) Hur kan det göras bättre?
18. När du hanterar/interagerar med olika system känner du då att du kan fokusera tillräckligt på körningen? Om inte: Vad kan göras för att din fokusering ska kunna bibehållas?
27. Ser du *problem* i användningen av systemen?

    Hjälp till med exempel om det behövs: överblick, förståelse, tillgänglighet (status), interaktion, säkerhet, litar för mycket på systemen.

Personliga inställningar

Nu kommer vi att gå in på några frågor om inställningar i olika system. Exempel på en inställning är något som förändrar systemets beteende, exempelvis att ställa in radion så den ger dig trafikinformation eller ställa in känsligheten i olika system, inställningar i navigatorn så som att ändra storleksförhållande på kartan eller val av information som ska visas, ex. bensinstationer, kyrkor.

Vi undrar om du…

19. ofta gör inställningar i olika system? I vilka situationer gör du inställningar i system? Finns det situationer då du inte gör inställningar i systemen? När? Varför?
20. Gör du inställningar i olika system under körning? Bör det vara skillnad på om och i så fall hur man gör inställningar före och under körning? Varför?

Aktiva säkerhetssystem

Nu kommer vi rikta intervjun mer specifikt mot de aktiva säkerhetssystemen, som alltså är system som ska förhindra olyckor.

Vi undrar om du…

21. känner att du har behov av olika aktiva säkerhetssystem? I vilka situationer känner du behov av systemen? (innerstads-/motorvägskörning)
22. Tror du aktiva säkerhetssystem kan förhindra olyckor? Varför/varför inte?

HAR INTE ANVÄNT AKTIVA SÄKERHETSSYSTEM

23. Vad har du för förväntningar på aktiva säkerhetssystem? Interaktion, tillgänglighet, inställningar. Vad har du för förväntningar gällande systemens funktion i innerstads- respektive motorvägskörning, eller i olika hastigheter?
30. Är det viktigt att ha möjlighet att kunna göra detaljerade inställningar separat i de olika systemen? Varför? Hur då?
31. Skulle du vilja ha möjlighet att göra övergripande inställningar som ändrar flera system samtidigt? Vad skulle dessa övergripande inställningar vara grundade på? Varför? Hur då?

HAR ANVÄNT/ANVÄNDER AKTIVA SÄKERHETSSYSTEM

24. *Vilka* aktiva säkerhetssystem har du använt?
25. *Hur ofta* använder du systemen?
26. *Varför* använder du systemen? Komfort/säkerhet? Känner du dig trygg med aktiva säkerhetssystem? Litar du på dem?
27. Ser du *problem* i användningen av systemen?

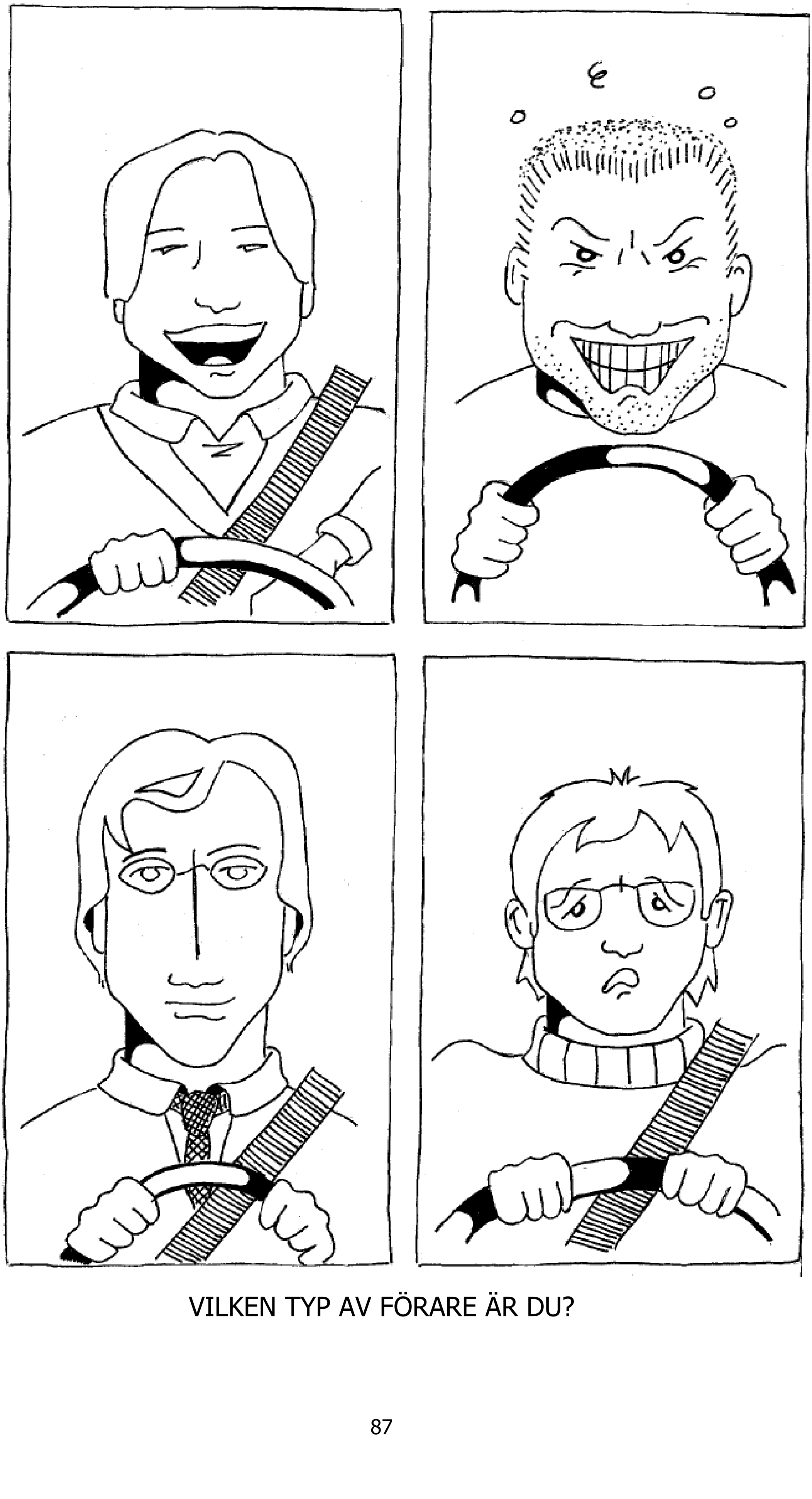
    Hjälp till med exempel om det behövs: överblick, förståelse, tillgänglighet (status), interaktion, säkerhet, litar för mycket på systemen.
28. Tycker du att du har den information du önskar om systemen? Finns det situationer då du saknar viss information? Finns det situationer då du tycker viss information är överflödig?
29. Hur skulle du vilja att de aktiva säkerhetssystemen fungerade? Önskemål om interaktion, inställningsmöjligheter, överblick.
30. Är det viktigt att ha möjlighet att kunna göra detaljerade inställningar separat i de olika systemen? Varför? Hur då?
31. Skulle du vilja ha möjlighet att göra övergripande inställningar som ändrar flera system samtidigt? Vad skulle dessa övergripande inställningar vara grundade på? Varför? Hur då?

Framtid

Då har vi kommit till den sista delen i intervjun som handlar om framtida utveckling. Vi undrar…

32. hur tror du att man kan komma att interagera med system i framtiden? Varför?
33. Hur tror du att man kan interagera med systemen utan display och knappar? Beskriv hur? Varför?
34. Hur ser ditt drömsystem ut och hur fungerar det? Varför?

APPENDIX B: QUESTIONNAIRE



VILKEN TYP AV FÖRARE ÄR DU?

1. Nedan finner du ett antal egenskaper som kanske eller kanske inte passar in på dig. Ange, med ett kryss (X), i hur hög grad du håller med eller inte håller med om att påståendet passar in på dig. Du ska ange i hur hög grad de båda orden passar in på dig, även om ett av orden passar in bättre än det andra på dig.

		Håller inte alls med	Håller i huvud-sak inte med	Håller i viss grad inte med	Håller varken med eller inte	Håller i viss grad med	Håller i huvud-sak med	Håller med full-ständigt
	Jag ser mig själv som:							
1.	utåtriktad, entusiastisk.	( )	( )	( )	( )	( )	( )	( )
2.	kritisk, grälsjuk.	( )	( )	( )	( )	( )	( )	( )
3.	pålitlig, självdisciplinerad.	( )	( )	( )	( )	( )	( )	( )
4.	ängslig, lätt upprörd.	( )	( )	( )	( )	( )	( )	( )
5.	öppen för nya erfarenheter, komplex.	( )	( )	( )	( )	( )	( )	( )
6.	reserverad, tyst.	( )	( )	( )	( )	( )	( )	( )
7.	sympatisk, varm.	( )	( )	( )	( )	( )	( )	( )
8.	rörig, slarvig.	( )	( )	( )	( )	( )	( )	( )
9.	lugn, emotionellt stabil.	( )	( )	( )	( )	( )	( )	( )
10.	konventionell, okreativ.	( )	( )	( )	( )	( )	( )	( )

2. Nedan finner du ett antal aktiviteter eller beteenden som kanske eller kanske inte passar in på dig. Var snäll och ange sannolikheten, för hur troligt det är, att du skulle engagera dig i respektive aktivitet eller beteende. Markera med ett kryss (X) hur väl vart och ett av nedanstående påståenden passar in på dig.

	Jag…	icke troligt	troligtvis inte	osäker	troligtvis	mycket troligt
1.	…använder alltid säkerhetsbälte hur kort jag än ska köra.	( )	( )	( )	( )	( )
2.	…sänker alltid farten när det ösregnar.	( )	( )	( )	( )	( )
3.	…kör oftast lite fortare än vad som är skyltat inne i stan om det inte är någon i vägen.	( )	( )	( )	( )	( )
4.	…kör gärna lite fortare än 110 km/h på motorväg	( )	( )	( )	( )	( )
5.	…håller alltid minst tre sekunders avstånd till framförvarande bil på motorväg.	( )	( )	( )	( )	( )
6.	…gasar oftast på när det slår om till gult för att hinna igenom.	( )	( )	( )	( )	( )
7.	…pratar inte i mobiltelefon när jag kör inne i stan.	( )	( )	( )	( )	( )
8.	…interagerar med/hanterar bilens system under körning i innerstad och motorvägskörning.	( )	( )	( )	( )	( )
9.	…tittar alltid över axeln innan jag byter fil.	( )	( )	( )	( )	( )
10.	…kör aldrig när jag känner mig trött.	( )	( )	( )	( )	( )

3. Nedan finner du ett antal påståenden som kanske eller kanske inte passar in på dig. Ange vilket svarsalternativ som bäst beskriver dig. För vart och ett av följande påståenden, ange med ett kryss (X) det alternativ som bäst beskriver dig.

		beskriver mig inte alls	beskriver mig till viss del	beskriver mig i huvudsak	beskriver mig väldigt väl
1.	Det skulle vara intressant att gifta mig med någon från ett annat land.	( )	( )	( )	( )
2.	Jag badar helst inte när vattnet är väldigt kallt även om det är en varm dag.	( )	( )	( )	( )
3.	Jag har oftast tålamod att vänta länge i en lång kö om jag måste.	( )	( )	( )	( )
4.	När jag lyssnar på musik, vill jag att det ska vara högt.	( )	( )	( )	( )
5.	När jag reser tycker jag det är bäst att planera så lite som möjligt och ta allt som det kommer.	( )	( )	( )	( )
6.	Jag håller mig borta från filmer som sägs vara skrämmande eller väldigt spännande.	( )	( )	( )	( )
7.	Jag tycker det är roligt och spännande att framträda eller prata inför en grupp.	( )	( )	( )	( )
8.	När jag besöker en nöjespark föredrar jag att åka bergochdalbanan eller andra fartfyllda attraktioner.	( )	( )	( )	( )
9.	Jag skulle vilja resa till plaster som är främmande och långt borta.	( )	( )	( )	( )
10.	Jag skulle aldrig vilja spela med pengar, även fast jag skulle ha råd med det.	( )	( )	( )	( )
11.	Jag tycker att det vore roligt att vara en av de första att upptäcka ett okänt land.	( )	( )	( )	( )
12.	Jag tycker om filmer med mycket explosioner och bilkrascher.	( )	( )	( )	( )
13.	Jag tycker inte om het och kryddstark mat.	( )	( )	( )	( )
14.	Jag arbetar oftast bättre under press.	( )	( )	( )	( )
15.	Jag har ofta på radio eller TV medan jag gör något annat, som exempelvis läsa eller städa.	( )	( )	( )	( )

		beskriver mig inte alls	beskriver mig till viss del	beskriver mig i huvudsak	beskriver mig väldigt väl
16.	Det skulle vara intressant att se en bilolycka hända.	( )	( )	( )	( )
17.	När jag äter på restaurang, tycker jag det är bäst att beställa något jag känner igen.	( )	( )	( )	( )
18.	Jag gillar känslan av att stå vid kanten av något högt och titta ner.	( )	( )	( )	( )
19.	Jag skulle vara bland de första i kön att anmäla mig om det var möjligt att gratis besöka månen eller en annan planet.	( )	( )	( )	( )
20.	Jag tycker det vore spännande att medverka i en strid under ett krig.	( )	( )	( )	( )

4. Din tillit till bilen

Nedan finner du ett antal påståenden som handlar om din tillit till bilen i allmänhet. Markera med ett kryss (X), på linjen nedanför varje kategori med påståenden, i vilken grad du håller med om påståendena.
Exempel

X

inte alls fullständigt

TILLFÖRLITLIGHET

- □ Bilen fungerar pålitligt.
- □ Bilen agerar på samma sätt under samma omständigheter vid olika tillfällen.
- □ Jag kan lita på att bilen fungerar korrekt.

inte alls fullständigt

TEKNISK KOMPETENS

- □ Bilen utför sin uppgift väl.
- □ Informationen från bilen är mycket kvalificerad.

inte alls fullständigt

FÖRSTÅELSE

- □ Bilens beteende kan förutses från gång till gång.
- □ Bilens beteende är lätt att förstå och följa.
- □ Trots att jag inte vet exakt hur bilen fungerar vet jag hur jag skall använda den för att göra det jag vill.

inte alls fullständigt

TRO

- □ När bilen ger sällan förekommande information är jag säker på att den är korrekt.

inte alls fullständigt

PÅLITLIGHET

- □ Jag kan lita på att bilen gör sitt jobb.

inte alls fullständigt

ANSVAR

- □ Bilen utför uppgiften den är avsedd att göra.

inte alls fullständigt

PERSONLIGT TYCKE

- □ Jag tycker om att använda bilen.
- □ Om bilen var otillgänglig och jag inte längre kunde använda den skulle jag sakna den.

inte alls fullständigt

DIN GRAD AV ÖVERGRIPANDE TILLIT TILL BILEN

ingen alls fullständig

5. Positiva och negativa känslor i trafiken

INNERSTADSKÖRNING

Karakteriseras av oss som: mötande trafik, låga hastigheter, korsningar, övergångsställen, trafikljus, andra sorts trafikanter, filbyten, precisionsskörning, ojämnt tempo, varierande körning, korta avstånd, inte så mycket plats, stor informationsmängd.

Den här skalan består av ett antal ord som beskriver olika känslor. Läs varje ord och ange i vilken grad du i allmänhet känner dig i *innerstadskörning*. Markera med ett kryss (X) för det alternativ som stämmer bäst överrens med hur du känner.

	mycket lite eller inte alls	till viss del	någorlunda	i huvudsak	i högsta grad
1. intresserad	( )	( )	( )	( )	( )
2. bekymrad	( )	( )	( )	( )	( )
3. upphetsad	( )	( )	( )	( )	( )
4. upprörd	( )	( )	( )	( )	( )
5. stark	( )	( )	( )	( )	( )
6. skyldig	( )	( )	( )	( )	( )
7. förskräckt	( )	( )	( )	( )	( )
8. fientlig	( )	( )	( )	( )	( )
9. entusiastisk	( )	( )	( )	( )	( )
10. stolt	( )	( )	( )	( )	( )
11. retlig	( )	( )	( )	( )	( )
12. alert	( )	( )	( )	( )	( )
13. skamsen	( )	( )	( )	( )	( )
14. inspirerad	( )	( )	( )	( )	( )
15. nervös	( )	( )	( )	( )	( )
16. bestämd	( )	( )	( )	( )	( )
17. uppmärksam	( )	( )	( )	( )	( )
18. pirrig	( )	( )	( )	( )	( )
19. aktiv	( )	( )	( )	( )	( )
20. rädd	( )	( )	( )	( )	( )

MOTORVÄGSKÖRNING

Karakteriseras av oss som: ingen mötande trafik, tvåfiligt, höga hastigheter, jämnt tempo, enformig körning, bra sikt, omkörningar, långa avstånd, bra med plats, liten informationsmängd.

Den här skalan består av ett antal ord som beskriver olika känslor. Läs varje ord och ange i vilken grad du i allmänhet känner dig i *motorvägskörning*. Markera med ett kryss (X) för det alternativ som stämmer bäst överrens med hur du känner.

		mycket lite eller inte alls	till viss del	någorlunda	i huvudsak	i högsta grad
1.	intresserad	( )	( )	( )	( )	( )
2.	bekymrad	( )	( )	( )	( )	( )
3.	upphetsad	( )	( )	( )	( )	( )
4.	upprörd	( )	( )	( )	( )	( )
5.	stark	( )	( )	( )	( )	( )
6.	skyldig	( )	( )	( )	( )	( )
7.	förskräckt	( )	( )	( )	( )	( )
8.	fientlig	( )	( )	( )	( )	( )
9.	entusiastisk	( )	( )	( )	( )	( )
10.	stolt	( )	( )	( )	( )	( )
11.	retlig	( )	( )	( )	( )	( )
12.	alert	( )	( )	( )	( )	( )
13.	skamsen	( )	( )	( )	( )	( )
14.	inspirerad	( )	( )	( )	( )	( )
15.	nervös	( )	( )	( )	( )	( )
16.	bestämd	( )	( )	( )	( )	( )
17.	uppmärksam	( )	( )	( )	( )	( )
18.	pirrig	( )	( )	( )	( )	( )
19.	aktiv	( )	( )	( )	( )	( )
20.	rädd	( )	( )	( )	( )	( )

APPENDIX C: POSTERS

Figure 41: Poster in A3 format used to represent inner-city driving (Volvo Newsroom)

Figure 42: Poster in A3 format used to represent motorway driving (Volvo Newsroom)

Figure 43: Poster in A3 format used to represent driving (Volvo Newsroom)

Figure 44: Poster in A3 format used to represent interior in Volvo S80 (Volvo Newsroom)

Figure 45: Poster in A3 format used to represent interior in Volvo S80 (Volvo Newsroom)

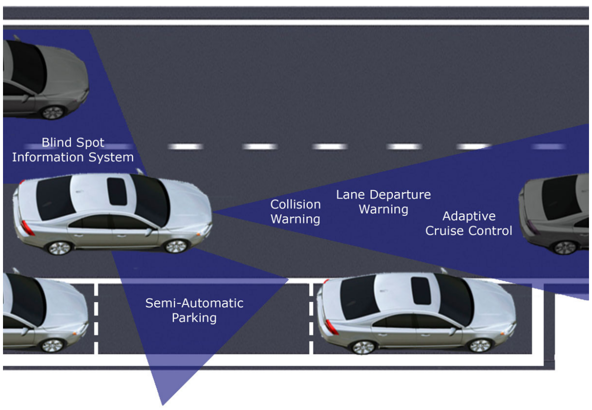


Figure 46: Poster in A4 format used to describe the functions of the active safety systems.

APPENDIX D: FUNCTION-MEANS TREE