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How to elicit user requirements for innovative future technology:

Creating and evaluating a new elicitation method in the context of highly automated driving

Masterthesis

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Abstract

Objectives: Taking the user into account during the whole lifecycle is an essential part of Requirements Engineering (RE) (Vavoula et al., n.d.). Otherwise, the design would not fit the users' vision and lead to difficulties using the products (Robertson, 2001). Therefore, in the beginning of a design lifecycle, requirements elicitation is an important step that takes users' opinions into consideration and focusses on their wishes. The difficulty arises how to let the user engage and experience a future he/she has not even thought of in a context that does not even exist. The challenge of how to extract user requirements from dreams evolves (Boehner et al., n.d.). Therefore, the research question was established how user requirements can be elicited in an innovative future oriented context.

Method: Based on a literature overview and evaluation criteria (specific for the innovative future oriented context) a method was established that is suitable for requirements elicitation. The established method of future workshops consists of three different parts. A pre-phase containing different studies (diary study, steering zone study) was based on material applied in the workshop on the users' level. The method was iteratively evaluated and further developed. The improved version was used to hold two workshops that were each focussed on a specific user group (elderly, mass-market).

Results: The data retrieved in the different phases could be structured in three main categories (general/technical, HMI, steering gestures). Furthermore, scenarios were derived from the workshop. Per workshop two concepts were developed that are described based on the presentations given by the participants and their paper-prototypes.

Conclusion: In general, it can be concluded that the goal to establish a method that elicits user requirements in an innovative future oriented context has partly been reached. General requirements could be elicited that were directed towards a future context, but innovative ideas contradicted and did not fit the traditional perspective of user requirements. Moreover, further research is needed that evaluates adaptions to the prototyping phase. To sum up, the developed method forms a starting point for further research in different contexts and the evaluation of adaptions.

Keywords: requirements elicitation/user needs, innovative future technology, h-mode, future workshop, automotive

Content

1. General Introduction

Over the last few years more and more innovations in technology have taken place that are focussed on applications in a ‘far future’ (Cagnin, 2008). An example of these kinds of future innovative systems is the concept of highly automated cars and the challenges that they entail. A great number of these challenges stem from human factor related issues (Akamatsu, Green, & Bengler, 2013). Challenges might occur when users’ expectations are not met and users are unable to relate to the system or accept it (Arndt, 2011). Therefore, it seems to be important to introduce the users as early as possible to the process. A design lifecycle that involves users in every step seems to be important (as stated by the participatory design method) (Vavoula & Sharples, 2007). By giving users the chance to pass their judgement and state their wishes and also to reveal the challenges they expect a system to have, the new technology can be adapted in the eyes of the users' requirements. Otherwise, a new innovative system could lack essential requirements the users would have wished for. This might then resolve in users not accepting technology and other usability issues (Arndt, 2011).

To fit the users’ expectations and engage them in the design lifecycle from the beginning in the area of requirements engineering (RE) provides a variety of methods and tools when it comes to user requirements. Each phase of the RE process is thoroughly studied and seems to offer a suitable range of different techniques for every context (Zowghi & Coulin, 2005). For example, interviews can be used to elicit user requirements. This user requirements elicitation phase forms an essential basis for the end product. But there seems to be one specific challenge when it comes to requirements elicitation for innovative technology. With innovative new technology that is not yet implemented, it becomes more and more difficult to apply a suitable method. Users are not aware of their wishes, because they relate to systems they have not even thought about yet (Robertson, 2001).

In order to elicit user requirements properly the user needs to be involved in the design lifecycle. But many methods stay at the level of only ‘talking about’ the product rather than really letting the users interact and engage with the new innovative systems (Bargas-Avila & Hornbæk, 2011; Vavoula & Sharples, 2007). In the context of highly automated driving, the task of eliciting user requirements might first seem feasible due to the variety of methods that are offered. But established methods such as interviews fail to let users interact and directly engage with the system. Without any kind of introduction or experience it might not be possible for the user to imagine what a system could even look like. Users might then indicate general requirements but the elicitation process would stay at this superficial level (Vavoula, Sharples, & Rudman, n.d.).

Due to the relevance of the current process of introducing new innovative technology for future use (e.g. highly automated cars) this challenge needs to be solved (Cagnin, 2008). Therefore, the case study of a project concerning the innovation of steering gestures for highly-automated driving is going to be applied. This context could provide insight in a prevailing topic (automated driving) while also providing a complex innovative context of a future oriented technological environment.

1.1 *Requirements engineering and its challenges*

Introducing users as early as possible into the lifecycle of a design process seems to be essential (Mishra, Mishra, & Yazici, 2008). Requirements engineering offers a variety of methods that can be used to cooperate with users in different contexts. One frequently used approach of RE is 'SWEBOK' (software engineering body of knowledge). This approach is widely spread and used in the area of software engineering. The SWEBOK approach provides guidance to RE by introducing four different phases (elicitation, analysis, specification, validation). These four different phases are described beneath. As described above using RE in an innovative future oriented context seems to be difficult for users to grasp. These challenges that are connected to this approach in relation to future innovative technology are further elucidated beneath. (Bourque & Fairley, 2014)

1.1.1 Elicitation, Analysis, Specification and Validation

The requirements elicitation phase consists of two main steps. The first step is 'requirements sources'. Different sources can be involved in the lifecycle that all need to be identified and further evaluated. Sources can be for example domain knowledge. This source is needed to acquire a reliable background and affirm and evaluate the focus and goal of the process. Other sources could be, for example, goals (e.g. providing motivation and priority of high-level objectives) as well as stakeholders (e.g. managing different viewpoints of a variety of stakeholder groups). The second step of this phase covers different elicitation techniques. A variety of different techniques exists to elicit requirements. Different techniques are focussed on different goals as well as different contexts (Abran, Moore, Bourque, Dupuis, & Tripp, 2004; Bourque & Fairley, 2014). A variety of elicitation methods is described in Section 2.1.

As stated in the description of the second phase of SWEBOK, the elicited requirements are then further analysed. This analysis is performed to detect conflicts between different requirements (e.g. requirements focussing on opposite standpoints). In this process, these conflicts are tried to be solved. As with the elicitation of requirements, the analysis phase also provides different methods (e.g. structured analysis). Based on these results a classification of the requirements can be performed. This classification can be done on a basis of different dimensions (e.g. functionality, source, priority). Afterwards a requirements negotiation can be carried out that provides conflict resolutions (resolving incompatible features) (Abran et al., 2004; Bourque & Fairley, 2014).

The third phase ‘specification’ deals with establishing a system definition document. This document can be applied to evaluate, approve and review the results in a systematic way. All requirements are assessed before the actual designing process is started. This step can provide an overview of possible risks and costs as well as providing a first schedule for the continuation of the process. The document can also be applied to validate and verify the process (Abran et al., 2004; Bourque & Fairley, 2014).

Based on these previous phases a ‘validation’ of the requirements can take place. The requirements document can be applied to ensure that all requirements are understandable, consistent and complete. This verification can be done in different ways (requirements reviews, prototyping, acceptance test and model validation) (Abran et al., 2004; Bourque & Fairley, 2014).

1.1.2 Challenges of RE in the context of future innovative technology

The SWEBOK approach gives the impression that an organized and structured approach can guide the researcher through a process to establish requirements. This approach is not only structured in different steps and phases, but also contains information on how to fulfil these different tasks (e.g. elicitation techniques, validation methods) while also indicating the objectives of each phase (Abran et al., 2004; Bourque & Fairley, 2014). Does this process also apply for requirements that are ‘undreamed’, meaning requirements users did not even think they had? These requirements are related to innovative technology found in a future vision. According to Robertson (2001) there are three different categories of requirements. The 'conscious' requirement describes a requirement the user is explicitly aware of. In contrast to that, the 'unconscious' requirement relates to the user not realizing that the requirement has to be explicitly stated and they are therefore unaware of it. An ‘undreamed’ requirement is rather different. These are requirements that do not even occur to the user because the users cannot imagine the related product, because they have never experienced it. For these requirements users need to be actively encouraged to imagine the product (Robertson, 2001). But how to extract user requirements from dreams (Boehner, Vertesi, Sengers, & Dourish, n.d.)?

According to Ihlström, Svensson, & Åkesson (n.d.) methods that have the specific intention to envision future technologies as well as their interaction with the users reach far beyond the traditional settings. The SWEBOK is currently limited to traditional settings and seems to be not able to incorporate future innovative technology. Moreover, Ehn & Malmborg (1998) state that 'new media and digital technology transform former design processes into new ways of working and constituting design' (p.1). These statements indicate that current traditional approaches (e.g. SWEBOK) are limited in granting insight in requirements in this context. If the focus of contexts lies in future technology, a re-thinking is required to create methods that really involve the user (Ihlström et al., n.d.).

Working with a future innovative technology context, users lack the experience and comprehension of the technology due to its novelty. If current methods and techniques are applied to this field, users miss the essential part of experiencing these systems. This absence can endanger the innovativeness of elicited design options (Ihlström et al., n.d.). But how can you let users experience a technology if this technology has not yet been invented or implemented? This challenge was also visible in a study of Inkpen (1999). In this study users were able to identify general issues that were important for the design. But this activity stayed at the general level and reached its boundaries due to the limited experience. It seems that preconceived notions and experiences with the technology restrain the innovativeness of this process (Inkpen, 1999). This indicates that users are influenced by their experience with similar technology and limited to imagine technology that stays prospective for them. According to Ihlström et al. (n.d.) an approach is needed that bridges the current experience of users with future thinking perspective. This transition could resolve the challenge and provide the advantage of encouraging users to be directly involved by creating and designing innovative new technologies (Ihlström et al., n.d.). In general, it can be concluded that in order to solve the challenge a method is needed that provides an interaction and transition between current activities and technologies oriented towards future innovations.

Providing this bridging between current experiences and future innovation generates its own challenges. According to Vavoula & Sharples (2007) users need to be involved in the technology lifecycle. Moreover, methods should be applied that provoke innovation in the design process. But current methods only stay at an inferior level of talking about future technology (Bargas-Avila & Hornbæk, 2011; Vavoula & Sharples, 2007). But in order to provoke innovation, users need to be directly engaged in the process and interaction. This direct engaging could provide the bridging/transition. But the challenge still remains how to engage the users with something that has not yet been implemented.

All statements that were mentioned above concentrated and focussed mainly on the first phase of RE 'elicitation of requirements'. Most challenges were encountered during the elicitation of user requirements. The question arises if other phases also introduce challenges for RE in relation with future innovative technology. This question is difficult to answer. If the challenge already occurs when eliciting requirements then there will be no data and an analysis, specification or validation cannot be executed. It might be that depending on the 'new' method applied for eliciting requirements for future technology novel challenges can arise that had not been thought of beforehand. These challenges can only be evaluated and further studied if a method to elicit these requirements is established and tested. Further evaluation of the possible requirements for future technologies is not the focus of this study but still seems to be relevant for further studies (depending on results of the 'new' method). There is also the chance that traditional techniques for the analysis/specification and validation phase are still applicable and can function properly. Still, this aspect should be kept in mind during later evaluation to connect the 'new' method to the RE approach and connect the elicited results to the whole design lifecycle.

In general, it can be concluded that RE seems to be an acknowledged approach but regarding the context of innovative future technology, there are still challenges that need to be solved. Users need to imagine future innovations that are not yet implemented and are therefore restricted by the limits of their experiences. The bridging between current experience and future technologies is needed to provoke an innovative process. Users need to be engaged to be completely involved in the lifecycle. But future technologies are not only not yet implemented but are also far too abstract and not comprehensible to simply let users engage with them. The statement still remains true that 'the choice of method must always be related to the situation at hand and the people involved' (Löwgren & Stolterman, 1999, p.14). This challenge for a future oriented context still remains to be solved.

1.2 *Case study*

The context of highly automated driving is applied to try to solve the challenge mentioned above. This technology provides a platform that combines innovativeness with a technology that is intended to be applied in the future. In addition, this area provides a variety of challenges in the human factors area on its own that still need to be solved (Akamatsu et al., 2013).

1.2.1 Automation and its challenges

According to Parasuraman & Riley (1997) automation takes place, when tasks and functions are executed by a machine which were previously carried out by a human. According to Akamatsu et al. (2013) there still exists a variety of human factors related challenges when it comes to automated driving. One main issue is the interaction between the system automation and drivers. If a system is able to take over certain driving tasks and can for some parts act individually, it seems as if the driver has the freedom to occupy with other tasks that are not driving related. However, if the system reaches its boundaries and demands the driver to take over control again the driver needs time to become aware of the situation again (situation awareness). At least 12-15 seconds are needed for the driver to be back in the loop (Vogelpohl, Vollrath, Kühn, Hummel, & Gehlert, 2016). Some situations demand the driver to stay attentive the whole time and be in the loop (e.g. road work scenarios). It seems to be important to keep drivers in the loop. Otherwise difficulties such as mode confusion or consequences due to the driver being out of the loop may lead to risk and restrain safety in major ways (Akamatsu et al., 2013).

The question arises what automation means in this context and how it is transferred. An automated system can vary from manual to fully automated. Possible levels could then be assisted/lowly automated, semi-automated, highly automated (in the loop) and fully automated (partly out of the loop).
The vehicle might then for example drive partly autonomously but the driver is always kept in the loop to be able to take over control. This control can be characterized as having the power to influence a situation. This implies that the driver is still able to influence the situation which relates to a high level of responsibility. If the driver needs to be responsible during higher levels of automation while being out of the loop, there seems to be the question who is actually in control/responsible. One solution could be to focus on manual driving so the driver holds the full responsibility. But automated systems have the power to enhance safety and comfort and should therefore not be disregarded (Howard & Dai, 2014). Neither manual driving nor full automated driving seems to perform well.

The h-mode tries to provide an opportunity to integrate the lessons that have been learned regarding human-centred automation. It has proven to offer a solution that combines high levels of automation and knowledge acquired regarding interaction between humans and automation (Flemisch, Kelsch, Löper, Schieben, & Schindler, 2008). The cooperation between driver and automated system in the h-mode focuses on always keeping the driver in the loop.

1.2.2 Modes of H-metaphor

A possible solution for this challenge could be a cooperative control. When sharing the control between the automation and the driver on varying levels, a safe interaction could be provided. This cooperative interaction can be described with the H(orse)-metaphor and is implemented with the h-mode. The H(orse)-metaphor describes a concept of an intuitive cooperation, interaction and communication between a horse and its rider that is transferred to the interaction between an automated system (e.g. in a car) and the driver. The h-mode focusses hereby on a haptic-multimodal connection between the driver and the automated system. Most of the time the h-mode is used in the context of active interface devices such as active pedals, steering wheels and active side sticks. All of those modalities are able to provide the driver with force and/or position feedback (Flemisch et al., 2008).

As described above the h-mode also relates to the different levels in the automation scale. These different levels/modes illustrate a dynamic distribution of control that characterizes the h-mode. The transition between these modes is fluid. A naturalistic transition could for example be that the drivers loosens his/her grip on the active inceptor and thereby signalizes the transfer of control to the automation. This example equals the transition from tight to loose rein. If the driver keeps his/her hands completely away from the active inceptor this could signalize the secured rein mode. To take over control again the driver can impose his/her hands on the active inceptor and furthermore increase his/her grip to signify the severe role of control.

As stated above these levels are depicted as ‘tight rein’ (horse is fully controlled and limited by the rider) relating to assisted automated level. In this mode the control lies mainly with the driver and the automation functions as an assistance (only low forces on haptic active interface). In the ‘loose rein’ (horse can act more independently and is no longer strictly controlled due to slackly held reins) the role of the automation increases. The driver is still in the loop and connected with the vehicle (haptic coupling with active interface). Later on, a third mode was added to the concept, the ‘secured rein’. This mode indicates that the vehicle is highly automated and the driver is partly out of the loop (Flemisch et al., 2008). This secured rein can be found in the context of working horses where the reins are secured to enable the person to act freehand. These different modes and their relations are also visualized in figure 1.

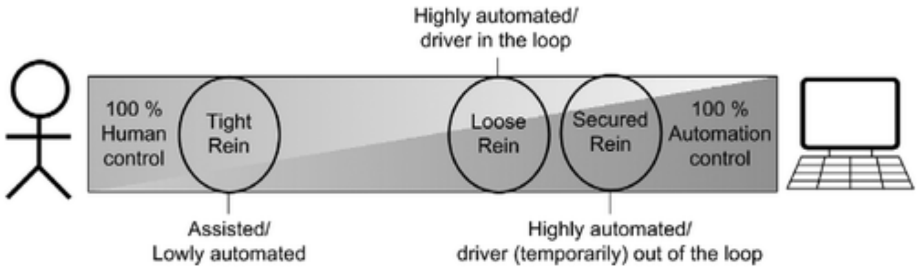

Figure 1. Scale of automation levels in the context of the h-mode

Figure 2 illustrates interconnections and the authority of control. On the left 'tight rein' the control lies with the driver. The driver interacts with his/her environment to act on his/her intentions. The 'automation' only assists but is not the main shareholder. In the 'loose rein' these roles are switched (middle picture). The main control is now with the automation. In contrast, the 'secured rein' on the right side clearly depicts that the role of the driver is restricted. The driver is temporarily out of the loop. The dashed line visualizes that there is no consistent cooperation/connection anymore (Flemisch et al., 2008).

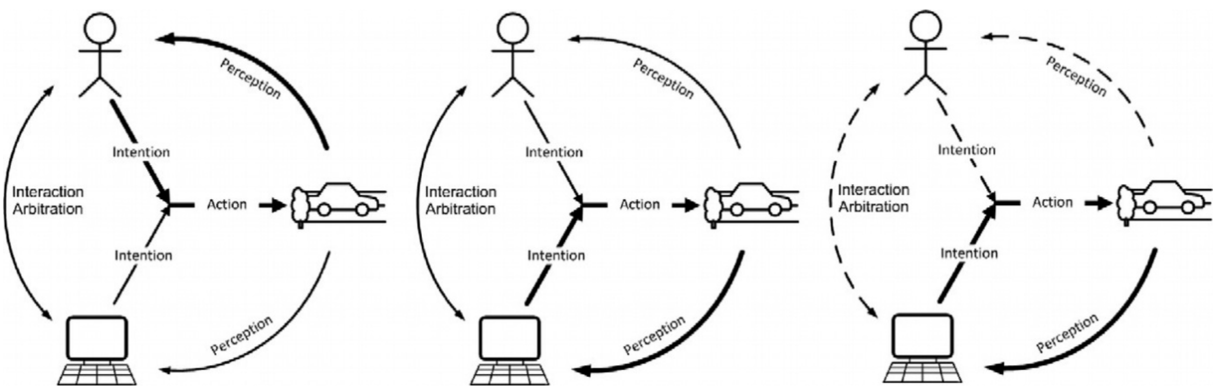

Figure 2. Depiction of different modes and their interconnections

1.2.3 Context of case study

As mentioned above there are still issues to be solved when it comes to highly automated driving (Akamatsu et al., 2013). The transition between the two different stages manual and fully automated driving still holds challenges. In order to be able to bridge these two levels and provide a safe way of driving while being able to keep the driver in the loop, the h-mode seems to be one option. It provides an intuitive way of interacting and a dynamic distribution of control. Furthermore, this intuitive way of interaction could also provide a suitable possibility for user groups with restrictions and disabilities.

User groups such as the elderly could profit when using a highly automated vehicle. Due to their limits regarding cognitive abilities they have difficulties to fully control a vehicle (Schlag & Beckmann, 2013). These limitations could foreclose their freedom (e.g. losing their driver license). Young drivers, disabled drivers as well as elderly drivers belong to groups that are limited in their mobility. For those user groups, options should be provided that support them in an intuitive way. Therefore, the goal should be to develop a system that further elaborates the concept h-mode while also incorporating a variety of user groups. Using the advances that were made in highly-automated driving and connecting and implementing those with the vision of cooperative control (h-mode), a new system could be designed that supports a variety of user groups to interact with a system and drive in a safer way. The main goal that should be achieved is a 'design for all'. The central idea of the project is to design a comprehensible design for steering gestures that can interact with a variety of users in an intuitive way. That means that an interaction takes place that can be initialised by the driver (as described with the h-mode). Examples of this interaction are manoeuvres that can be controlled/initialised by the driver (e.g. lane-changing, stopping, starting, turning and parking). Due to managing these kinds of manoeuvres via steering gestures, the driver could be provided with not only a more comfortable way of driving but also with more security and a faster kind of interaction.

Therefore, the design goal is a concept for a gesture control that can be used by different user groups (average, young, disabled, and elderly). That means that depending on the developed user requirements, different varieties of design aspects can be applied. The product should also apply haptic-multimodal ideas for steering gestures. This system should be adaptable to assure safety and an efficient way of usage for different end users.

1.3 ***Overview study and research question***

The design goal of the project described above is a haptic-multimodal gesture control that can be used by different user groups (average, young, disabled, and elderly). The final design should be adaptive to their different requirements. That means that depending on the elicited user requirements, a different variety of design aspects can be applied. To achieve this goal, requirements need to be established that can serve as a base for possible design solutions/ideas. In order to come up with a solution that fully represents the end user, all user groups need to be part of the research from early on (Robertson, 2001).

As described above, the innovative and future oriented context of automated driving challenges the approach of requirements engineering. If data is acquired by using traditional methods, the results might not be valid because they account for wishes that originated from a misconceived perspective that lacks experience with the new technology (Inkpen, n.d.). This might not be noticeable during the progression and development of a prototype, but later on during the evaluation of the product. The acceptance might suffer due to this missing experience (Arndt, 2011).

The study that is going to be performed consists of different parts. The first part focusses on seeking out the most suitable method for user requirements elicitation in context of the project framework. That is the reason why the first step of this study is going to be the development of a suitable method. This method should elicit user requirements for a future system in the context of the project.

Therefore, a literature review will be executed to give an overview on different methods of requirements elicitation. Advantages and disadvantages are presented with every method to facilitate a later judgement. Based on the context of the project criteria will be established to support the assessment of the different techniques. The different methods will then be evaluated based on the established criteria. Based on these results a concept will be established that combines and/or adapts a suitable method for requirement elicitation for future technology.

In the second part of the study the method is tested and iteratively evaluated and improved further. This iterative process can assure that users are sufficiently integrated and the method is based on their standpoint of experience and knowledge of the topic. After preparation and planning of the new method, the method is used with two different user groups (elderly, mass market). Based on the established method the acquired data is then further analysed to evaluate the performance of the newly designed approach.

As described above the goal is to establish a method for innovative future technology to elicit user requirements. Therefore, the research question was established:

‘How to elicit user requirements for innovative future technology?’

2 Methods and techniques to elicit user requirements

2.1 *Overview of methods*

Requirements engineering uses and applies a variety of different techniques to elicit user requirements. Each technique is more or less suitable for a certain area or a goal that needs to be reached. Therefore, each elicitation technique comes with advantages as well as drawbacks when applied.

Methods such as conducting *'interviews'* seem to be clearly related to eliciting user requirements and forms one of the most traditional methods (Zowghi & Coulin, 2005). Interviews are conducted using a predetermined set of questions to derive specific information about a topic. Therefore, the questions need to be specified beforehand based on the direction and goal of the project. There are different kinds of interviews (structured/semi-structured). During these one on one discussions, open ended questions can be used to find information gaps. Close ended questions can be applied to confirm and validate the process (Maguire & Bevan, n.d.).

Conducting interviews as a method to elicit user requirements is generally considered an effective technique. Mostly it is effective for gaining insight and an in-depth view on specific aspects. Moreover, this method forms and efficient way to collect a large amount of data in a short amount of time. However, the success of this method depends greatly on knowing what the right questions are and when these questions should be asked. The method is limited when investigating novel ideas. Furthermore, a variety of different standpoints is reached rather than a consensus statement (Zowghi & Coulin, 2005).

Another technique to elicit user requirements is the *questionnaire* also referred to as user survey. This method can be applied during the early stages of user requirements elicitation. The survey may consist of open as well as close ended questions. The method provides a quick way to elicit user requirements from a large number of users. Furthermore, it can be useful as a checklist to see if all fundamental elements are addressed. The quantitative data can also be later analysed with a statistical analysis. But it seems that this method is only effective if the concepts and boundaries of the domain which is used are fully understood. Furthermore, the in-depth knowledge that can be elicited is limited. Therefore, there is a lack of opportunity to expand on new ideas. During the process, it is difficult to provide clarification for participants. This might cause misunderstandings explicitly when used in an innovative context (Zowghi & Coulin, 2005).

Another technique is the *focus group*. A focus group is a collaborative meeting that usually has six to twelve attendees. Issues that need to be tackled are identified by a discussion in a group with a cross-section of stakeholders. The method focusses on a stimulation of ideas via a discussion of different ideas and opinions. By applying this method, a collective view can be elicited. The process is suitable early on during requirements elicitation. The method involves stakeholders directly and promotes cooperation as well as discussion. Focus groups may come with the disadvantage that it is hard to engage all members. The direction of the discussion can be influenced by dominant members. This peer pressure can lead to biases in the process. The method of Delphi groups can compensate for this limitation (anonymity) (Zowghi & Coulin, 2005).

The method of *scenarios* provides a narrative and specific description of current and future processes. Scenarios include actions and interactions between the user and the system. These interactions can be discussed with the user directly to determine what they like and also don't like about the system. The main goal of this method is to generate user requirements as well as usability aims. Although the method can be used early on in the process, it is also useful to validate and understand requirements later on. The method can also be applied to develop use cases and to generate contexts for evaluation studies (Maguire & Bevan, n.d.).

Brainstorming also forms one of the most common techniques to elicit user requirements. During a brainstorming session users can inspire each other while trying to generate ideas. These ideas can then be clustered to improve the outcome of the session. The researcher leads the discussion and sums up results to assure a consensus of the whole group and states which opinions are specific to individuals. The technique can be applied early in the process to resolve new ideas. Furthermore, the message encourages innovative thinking. Most of the time less than one hour is needed to obtain useful data. Although a rapid elicitation can be guaranteed, the objectives of sessions need to be determined beforehand. Moreover, it is not possible to cover specific design aspects (Maguire & Bevan, n.d.).

The *theatre technique,* a form of the Wizard of Oz, can also be applied to elicit user requirements. The theatre technique comes with the speciality to apply an open curtain while prototyping. The wizard processes inputs from users and emulates the system output. By applying the open curtain, a direct interaction can be provided. The method can be focused on the whole solution or just a specific area. It provides a great interaction between the wizard and the end-user. Furthermore, it comes with the option to quickly build and refine a prototype. There is also an early detection of usability problems in response to user feedback. The method does not only allow exploring requirements but also lets the research gain insight in usability issues at an early stage. Due to this close involvement with the user, the researcher can gain valuable insight. The method is very time consuming. It also asks for a high commitment on resources compared to other prototyping techniques (Zowghi & Coulin, 2005).

The *Delphi method* is a structured communication technique. It uses different rounds where participants first provide an anonymous statement on specific questions. The statements are summarized and given to the participants during the next round for feedback. The main goal is to derive a forecast/ decision after a specified number of rounds. As mentioned above, this method can compensate groups with dominant participants (Zowghi & Coulin, 2005).

The method of *future workshops* belongs to the participatory design. The focus lies on understanding current problems and then finding innovative ways to eliminate current problems by considering potential future scenarios. The approach of future workshops is action oriented. Three phases form the base of the workshop. The first phase, also referred to as critiques phase, investigates the topic critically. For example, a structured brainstorming can be applied so that participants have the chance to criticize the current situation based on their experience. This criticism can then be formulated as statements that keywords can be derived from. In the following phase, also referred to as fantasy phase, the negative statements from the session before are inverted to positive statements. A new brainstorm session can be applied to derive future visions and concepts. In the last phase, also referred to as implementation phase, participants have the opportunity to present their own future vision. The general structure and the techniques applied in the future workshops depend on the context and usage as well as goal. For example, a trigger phase can be added that increases awareness on current possibilities and state of art technologies (Ihlström et al., n.d.; Zowghi & Coulin, 2005).

This method enables the user to think creatively about future system. Foremost, it is useful when participants have little experience with processes of creative decision-making. Users are involved in creating the preferred future rather than being subjected to decisions. This method also comes with the possibility to combine different techniques as well as adapt techniques depending on the context. Due to the open context, the results can be too ambitious. This issue might be compensated by adding a trigger phase to the workshop. Still a long preparation time is needed to execute a future workshop and the usefulness is not guaranteed (Ihlström et al., n.d.; Vavoula et al., n.d.; Zowghi & Coulin, 2005).

Storyboards can also be used as a technique for eliciting user requirements. They represent sequences that show relations between user input/actions and the system output. A storyboard can be seen as a static representation of a future system. The method can be used during early stages and can function as designed feedback. Due to the static representation, a storyboard can help a stakeholder to visualize an experience. However, storyboards lack an interactive quality with the user. There is no possibility for the user to directly engage with the system (Zowghi & Coulin, 2005).

The method of ethnography uses this field research involving and studying participants' everyday lives. The types of observations can be passive as well as active. Data is collected for participants observations, interviews, audio or video recording, observer logs, artefact collection, diaries and photographs. The traditional ethnography studies are long-term studies that can last from weeks up to years. The main goal is to understand the circumstances and the environment of users. Using this method can give insight in aspects that no other technique will provide. Due to the long-term focus of the study the method can be very time-consuming. This results in a huge amount of data. Furthermore, there is the chance of an observer bias (can be compensated if video observation is applied)(Maguire & Bevan, n.d.; Zowghi & Coulin, 2005).

Another method is the technique of diary keeping. Diary keeping belongs to the method of experience sampling. Participants are able to capture their experiences and activities. The recorded experiences can guide the researcher by eliciting user requirements. Based on the sampling strategy the duration differs (days to month). To be able to collect data the participants need to be sufficiently motivated to pursue the completion. This might be difficult in some circumstances. Depending on the used platform (e.g. paper pencil method, smartphone based) other difficulties such as extra costs and care for the equipment arise. Diaries are able to provide insight on current experiences and activities but need to be designed carefully to function properly.

2.2 ***Challenges to future innovative user requirements – description of criteria***

In order to determine which of the methods fits the innovative future oriented context and aim of the project best, criteria will be established that support an evaluation. Based on the challenges defined above, criteria are going to be established that summarize the most relevant and essential pain points. The main goal of this study is to elicit user requirements in the specific time frame of the thesis and the project. This suggests that the methods should match these goals at the end of the process. Not only should the final goals be reached (user requirements) but the chosen method should be '*applicable in the framework of the context'*. It might be that specific methods are not suitable when used in the context of highly automated driving or cannot even be applied.

In order to assure a perfect fit for the context mentioned above, the methods should be '*adaptable/combinable'* (Mishra et al., 2008). That implies that the method is not fixed and a specific procedure needs to be followed. The method should be adaptable to be able to be applied to the automotive future oriented context as well as different user groups.

One of the most important criteria is *'open endedness'* (Vavoula & Sharples, 2007). This criterion describes a method that is not restricted to specific questions and is able to connect participants with future systems. Due to advanced technology that has not yet been experienced by many users, the difficulty arises that they are not able to imagine using such a system. There is no real model of how a highly automated car works. For example, users might experience difficulties imagining which task an automation can take over and in which situations because they try to base their ideas on current experiences which do not relate to the future context (Olphert & Damodaran, 2004). Therefore, the method should be 'open' to be able to integrate new creative techniques to have a mental model in mind (Robertson, 2001).

In order to visualize the new technology in mind but to actually relate and let the users engage with the system, the criterion *'relate/engage users and system'* was established (Inkpen, n.d.). The main goal of this criterion is to assure that an interaction can take place between the new system/ technology and users and can bridge both sides to form a transition (Ihlström et al., n.d.). The method should enable the users to directly experience the new system. This seems to be important because participants might only be able to fully imagine the system if they are able to interact with the system (Vavoula & Sharples, 2007). This interaction could then provide the participants with new insight regarding requirements but also related challenges when it comes to the design (Inkpen, n.d.).

Since the applied future context of the project is at the beginning stage, it is necessary that the chosen method is applicable to be used *'early in a process'*. It might be that methods are more suitable for later on evaluation of usability issues. Another difficulty that could arise if this criterion is disregarded is that a method could demand development steps and other material that has not yet been established. Therefore, the criterion '*useful early in the process'* needs to be considered in the evaluation process.

As with every project, there is only a limited time frame as well as budget that need to be considered during the design of the method. For example, the method should not last longer than one month; otherwise it requires too much time of the participants (workshop that lasts for several days) due to feasibility. Another important aspect that needs to be considered is that the costs are feasible in the frame of the project. This implies that the material that is used is easily accessible or already available and present. For example, a focus group could be carried out in any large room. Therefore, the criterion *'accessible resources'* is chosen for the evaluation of the methods (Vavoula & Sharples, 2007).

The criterion 'accessible resources' stands in close relationship with *'minimal participant training'*. Due to the different user groups and the focus on the approach 'design for all', different user groups will run through the chosen methods. In order to prevent extra costs and time, the method should be used by different user groups without any need of pertaining.

2.3 *Evaluation of methods*

The criteria that were established regarding the future innovative context and goal of the project will now be used to evaluate the different methods described above. Based on the criteria and the advantages and disadvantages of each method a rating and evaluation will be performed with three different researchers that discuss each method. Based on this discussion each method is categorized per aspect. There are three different categories. The ‘+’ indicates that the evaluation aspect is completely fulfilled. In contrast, a ‘- ‘implies that the method does not comply the aspect at all and might also have a negative impact. If the method does not fulfill the aspect and has shortcomings regarding specific aspects, but still has the potential to tackle and/or address an aspect, it was rated with 'o'. The table below visualizes the evaluation of all methods and the criteria. A description of the rating and evaluation is provided beneath.

Table 1.

Rating of different methods

Method	**Open-ended ness**	**Adaptable**	**Useful early in process**	**Relates users and technology**	**Minimal participant training**	**Accessible resources**	**Fits context of project**
(semi-)structured Interviews	-	+	o	-	+	+	-
Focus groups	-	+	o	-	+	+	-
Brainstorming	-	+	o	-	+	+	-
Theatre technique	+	+	-	+	o	-	+
Scenario building	+	o	+	o	o	o	+
Questionnaires	-	o	-	-	+	+	-
Future workshops	+	+	+	+	o	o	+
Delphi round	-	+	o	-	+	o	-
Ethnography	+	+	o	-/o	o	-	-
Diary study	+	+	+	o	o	+	+

Note. '+' completely fulfilled, '-' not fulfilled, 'o' potential to address specific aspects

The method of conducting (semi-) structured interviews can be adapted, it has accessible resources and no extra time would be needed to train participants. But considering that the method is not open ended and also does not relate the users to the new technology, the elicited requirements would not fully elucidate the required goal. It might be that due to participants having difficulties relating to the technology or even imagining how it could work (mental model) the results could be superficial and might not even emphasize the real requirements/issues (Robertson, 2001). Then the established material could be further used to create a prototype but later on the product would not be accepted by the end users, because the wishes they had towards the system beforehand were not fully understood (Robertson, 2001).

The same issues can be seen with the methods 'focus groups' and 'brainstorming'. These methods might have the advantage to be more interactive due to a discussion with others on ideas but in the end these methods also have their limits when really relating users to the new technology, because they cannot provide any direct engagement (Inkpen, n.d.). These methods stay more on the 'talking about' level than really providing a direct interaction with the technology and the user (Vavoula & Sharples, 2007). With the method 'questionnaires' this seems to be even more difficult. Questionnaires lack the aspect of being interactive. Compared to questionnaires participants of a focus group have the opportunity to direct questions or difficulties in understanding the new technology directly towards the interviewer as well as the interaction between the participants. Furthermore, the interviewer can directly intervene if there are misunderstandings or other complications regarding the understanding of the topic. The interviewer has also the possibility to pick up relevant and interesting aspects and thoughts to develop them further in the discussion. All these aspects are limited or restricted when using questionnaires. Therefore, questionnaires do not seem to be useful.

Methods such as the theatre method could also be applied. They enable the user to interact with the system and simultaneously work on possible requirements. Furthermore, the method can be adapted. This means that the method can be used in combination with other techniques or parts can be implemented in other techniques. The disadvantage with this method is that a base is needed to work on. Use cases, for example, are needed if a user is asked to think about wishes and requirements during a scenario (in a driving simulator). A base should be established beforehand (use cases as well as scenarios) in order to insure that the method can be applied effectively. Another disadvantage that should not be disregarded is that the material (e.g. specific simulator equipped with two steering options that are coppled) that is required for this method is not easily to be obtained and related to costs for development. This would not be pragmatic.

According to the rating in table 1, the method of 'future workshops' seems to be the most appropriate method in this innovative context. The method is especially developed to provide users with a direct interaction of the new system and creates requirements, wishes, scenarios and first prototypes together with the user in different phases. Furthermore, it seems that these different phases can be structured and adapted based on the context and goal. For example Ihlström et al. (n.d.) used a scenario building phase and refined the method depending on their needs. Also, a 'trigger phase' can be added (Ihlström et al., n.d.). Usually the focus of these kinds of workshops lies on being as open as possible to give the participants the opportunity to think about their own possible future scenario. But if the focus should be put on a specific aspect (e.g. steering gestures in h-mode), a future scenario and framework of the context can be presented to the users to limit the scope of the workshop and point out the focus. The challenge comes when finding the perfect balance between giving the participants too much information and not introducing them enough. Another disadvantage regarding this method comes with the efficiency. To prepare and develop these kinds of workshops a greater timeframe is needed than with other techniques. But conducting these workshops also provides a lot of needed data. For example, the different phases can function to elicit user requirements, establish use cases and also think about a first prototype.

2.4 *Future workshops*

In order to try to establish a suitable method to elicit user requirements, current methods needed to be studied beforehand. By evaluating current methods by criteria that were based on the challenges that derive from this innovative context, an overview could be established. This overview provided an option for constructing a suitable method: adapted future workshops. The approach of future workshops belongs to the field of participatory design. Future workshops are focussed on action oriented future studies. Since other methods fail to take the future into account, the method of future workshops is going to be used and further developed in this study. These workshops are created to enable users to dream up and employ creative ideas to improve society. Future workshops provide a tool of envisioning future technologies. Based on existing methods, the future workshop aims at transcending users' current perspectives to link them to future forms and uses of technology. The focus is directed towards future technologies as well as action oriented activities. This balanced interplay forms the core of the approach. The original structure of future workshop consists of three main phases (see section 2.1). In addition, a preparatory phase is sometimes added, because it aids in compromising the decision on a topic and considers the practical arrangements. In the original set up of the workshop this phase also contains a general introduction to the workshop.

2.4.1 Previous studies

Previous studies applied the method of future workshops, but with adaptations and variations regarding structure and content. The core vision of letting the users actively experience an innovative and future oriented context is similar in other studies. Still, although commonalities are visible in previous applications of the workshops, there are still degrees of freedom detectable that differentiate the variety of adapted versions. Two variations of previous studies are outlined beneath.

The study by Ihlström, Svensson, & Åkesson (n.d.) utilizes an adapted version of the approach for their e-paper project. They apply the three main phases with variations. The workshop starts with a visioning phase. This phase contains an introduction as well as the critique part (brainstorm session). In addition, Ihlström et al. (n.d.) add a trigger part to the phase based on the adaption made by Arvidsson, Ihlström, & Lundberg (2002). This modification facilitates participants' awareness of the future technology and its limitations. This phase is then followed by a scenario building phase (scenario building and presentation of results). The workshop is finished with a mock-up phase. Here the participants are encouraged to create and present their mock-up concept.

Also Vavoula & Sharples (2007) conducted a modified version of the future workshop. Their future technology workshop consists of seven different phases: Imagineering, modelling, role play, retrofit, every day, future fit, requirements. Different techniques used in the different phases form the base of this future technology workshop. Six participants followed the workshop with three facilitators for a whole day.

2.4.2 Creating the most suitable version

Based on the rating, evaluation and information gathered of application, the future workshop will be developed. In order to keep the workshop short and efficient, the three main phases should be maintained. In the used context, the seven phases used in the Vavoula & Sharples (2007) study would demand too much time from the participants. Moreover, the preparation would not be time efficient. Some phases of the future technology workshop are shortened to only 15 minutes (e.g. Imagineering). It is important to capture every idea developed during the workshop. Therefore, discussions and presentations of the results should not be limited as they might be essential for ideation. A combination that integrates the most suitable phases and techniques of the original version and the adapted version created by Ihlström et al. (n.d.) seems to be suitable. Based on these considerations the future workshop depicted in figure three was developed.

The method 'future workshop’ is based on current methods, but is adapted as well as combined with other methods. This customization is executed to find the most suitable fit for the context. In order to stay as user centred as possible, material directly acquired by users is applied as well as different iterations of the method are performed.

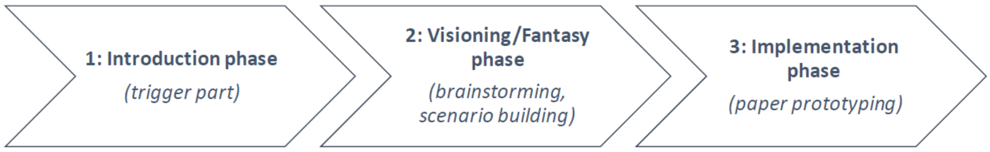

Figure 3. Set-up future workshop

2.4.3 Trigger part

As showed above, phase one contains a trigger part to direct the scope and framework of the future vision and facilitate the ideation. Ihlström et al. (n.d.) for example applied a variety of triggers such as technology triggers (e.g. video clips and prototypes). However, the input presented to the participants might have negative consequences for the innovative progress of the workshop (Ihlström et al., n.d.). The selection of the chosen material (different kinds of triggers) needs to be carefully considered to prevent any misleading and restricting priming of participants. On the one hand, users need to be free to tear from their current experiences to be innovative, but on the other hand it is also important that the results are applicable for further development. This application is only possible if the options are somewhat limited. The main challenge with this additional trigger part is to balance this limit and set the perfect boundaries. Users should be primed to focus on a specific area (e.g. cooperative steering gestures) but also to stay innovative and actively engage in a possible future concept.

The trigger part that will be used in these workshops should be focussed on giving users an idea of the concept of the h-mode. There might be the difficulty for users to relate to why a cooperative interaction between the automation and the driver is needed. The phase can be used to make sure that participants focus on the correct level of automation. The goal of the project is to create a concept that is based on a cooperation derived from the h-mode. Therefore, pre-studies are needed to create a vision directly derived from the users themselves.

2.4.4 Further adaptions

Not only can the trigger part be based on these pre-studies, but also the whole workshop can benefit if focussed on the current user perspective. Using studies such as diary studies can provide an impression of current issues that users encounter when driving with assistance systems. These scenarios can then be further used during the workshop to further elucidate the context and provide examples if questions occur. Due to focussing on this close interaction with the user during the whole development cycle of the method, a suitable interaction level can be applied. According to Arndt (2011) it is important to stay on the users' level during RE.

As visualized in figure three, the second phase combines the critique and fantasy phase of the original version as well as the visioning and scenario building phase of the modified version of Ihlström. Ihlström et al. (n.d.) also applied a mock-up as the last phase. In the original concept, an implementation was scheduled as well. The paper-prototyping technique in combination with generative tools forms a low cost and easy to use base. Furthermore, participants only need minimal instructing on the material which benefits a minimal participant training. Moreover, these tools encourage collaboration effectively (Sanders, 2000). According to Sanders (2000) the focus of the process should be on users' dreams and aspirations and not be restricted and limited by technology. Therefore, it was decided to apply paper prototyping in the last phase.

2.4.5 Pre-phase

As discussed above there seems to be no single one 'perfect' method. Every method has its advantages as well as disadvantages. Therefore, it was decided to adapt the most suitable method and try to create the most suitable fit for that context. The method of future workshops seemed to be applicable regarding the context of the project (especially when including a ‘trigger phase').

However, future workshops lack one important quality as they need additional material beforehand to base a workshop on. It is essential to fully understand the current situation as well as experience and visions of users with automated driving. Therefore, it was decided to add a 'pre-phase' to the workshops. The most appropriate and suitable method for a ‘pre-phase’ seems to be a diary study. To get an insight in their experience, participants can keep track of their daily driving via a driving diary.

The combination of a workshop that can relate users to the new technology and concept and lets them directly interact/engage and be creative seems to be the appropriate method to elicit user requirements in an innovative context. In addition, the diary study can add an essential value and gains insight into the current experience and vision to provide the optimal base for material that can be used in the workshops. Using material that is directly elicited from the user groups might offer a more matching vision than when established by experts. Furthermore, a study focussed on users’ perspectives on steering gestures in general can be added to gain a first insight into their standpoint.

2.4.6 Iterative development

The method that will be used in this study consists of different parts and iterations. First, a general study on steering gestures will be performed. This study can be useful to gain insight in users' perspective towards the topic 'steering gestures' in general as well as evaluating key questions and use cases. These use cases as well as current driving experiences can also be extracted via a diary study. To evaluate the diary study, an iteration with a pilot version will be carried out. A pilot study is used to assure that the new methods will be able to fulfil the goals in a realistic setting. When creating and adapting new methods it seems to be essential to test them out to iteratively develop the most suitable method. As there are no indications in literature on the performance (it is only possible to deduce and assume from similar studies) of the method, it is important to acquire knowledge on how long the workshops will take and what general issues need to be adapted. These pilot studies are then followed by the actual studies (e.g. diary study and future workshop).

The studies mentioned above all elicit material that is used as a base for the future workshops. By using material directly from user groups, a more grounded base of the workshops can be assured that matches their current perspective. In order to be able to evaluate the strategies and techniques used in the workshop a pilot study will be performed. This iteration provides the option to improve the workshop further (Nielsen, 1993). Below visualization can be found that shows the process in detail.

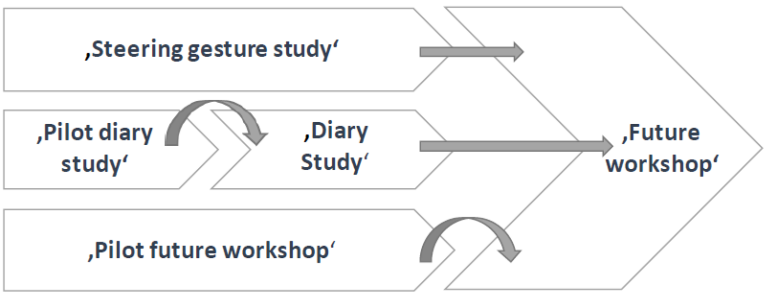

Figure 4. Iterative design of study development

3 Pre-phase - steering gesture study, (pilot) diary study and pilot future workshop

As described above the method of 'future workshops' was chosen in addition to pre-phase studies. Therefore, three studies were conducted as a pre-phase (see arrows in figure 4 on left side). These studies were developed and executed parallel to each other. Based on the method of experience sampling, a diary study was conducted. In the pilot study the participants (n= 3) received 15 copies of a predesigned form. The form can be separated into three different sections (basic information questions on each trip, experiences of the ride (SAM-scale), relevant events and evaluation on these rides). An event sampling in a diary format was completed by all participants in a time frame of one to two weeks. The material was examined and main pin points (steering gestures, difficult scenarios, wishes and requirements for future systems) were noted down that seem to be relevant to further discuss with the other researchers. Based on the results and feedback given by the participants, conclusions were derived to enhance the study.

An instruction was added to the updated study booklet. Furthermore, the different sections were adapted to refine comprehension and clarify the intention of each section (examples are added, abstract terms are described, visualizations are clarified). The updated version of the diary study was completed by two participants. Based on the data elicited in this study and the pilot version, key aspects (scenarios, experiences with assistance systems) are filtered to be used in the future workshops. This insight might help to stay on the same level as the current user perspective to provide participants with examples that guide them in the intended direction. For example, the elicited scenarios and experiences as well as wishes can be applied in a trigger part of the future workshop. These options might be easier to grasp for participants because they were directly derived from their user group.

Instructions as well as general implications of the project needed to be tested beforehand. Therefore, a study was conducted that tried to gain insight in the participants vision of 'steering gestures' as well as trying to evaluate and establish a guideline for questions (for reference points in future workshops). Ten participants took part in the within subject design which was employed. The study took place in a driving simulator. In front of the simulator a canvas was placed which was used to show videos of the different maneuvers. Per maneuver (six in total) one video was selected that visualized the scenario from the driver's perspective. The scenario videos were shown to the participants. At the critical point (e.g. shortly before the traffic lights turned green) the video was stopped. The participants were asked to imagine how they would try to initiate the specific maneuver with a steering gesture. Based on this study key question were developed. For example, questions related to feedback from a system/steering modality were added.

Furthermore, a first concept of the future workshop was tested out. Six participants took part in the pilot workshop focused on creating a first steering concept for a flying car. In total, the workshop took about three hours. In the beginning of the workshop the participants were informed about general aspects of the workshop (e.g. duration). Moreover, the main intention of the workshop was communicated to the participants. The participants were asked to give feedback whenever something was unclear or they had any suggestions for further improvement of the procedure. After the trigger part (including test 'fly' in simulator) a brainstorming session was executed followed by a prototyping phase. The workshop was finished with the presentation of the concepts and a short feedback and evaluation round with the participants. Depending on the phase a variety of evaluation points can be considered.

Based on these evaluations of the different pre-studies and the data elicited by the pilot studies, the structure and framework of a future workshop was established. All considerations derived from this pre-phase are taken into account. A detailed description of the different pre-phase studies can be found in Appendix A. The data and material gathered from this pre-phase was applied in the future workshops described beneath.

4 Future workshop

4.1 *Design*

In this study, an explorative design research was applied. Based on the participatory method of future workshops a workshop was developed that fit the context as well as fulfilled the criteria. The workshop consisted of three phases ‘introductory phase’, ‘visioning/fantasy’, and ‘implementation phase’.

4.2 *Participants*

The study consisted of two parts. The future workshops were divided into two separate sessions. In each session six participants took part. One session was focussed on the user group 'elderly' (loosely defined according to Salvendy (2012) ‘old’ = 65-85) with a mean age of 67 years and a standard deviation of 10.89 (age range: 48-79). The amount of female and male participants is evenly spread. The results of the pre-screening show that every participant of this group can be categorized as somewhat technically affine. Furthermore, four of the six participants indicated that they already have experience with driver assistance systems. Every participant has a driver's licence as well as driving experience of a variety of annually driven kilometres.

The other workshop group was chosen to represent the mass-market. The participants were explicitly chosen based on their technical affinity (N=6) and experience with driver assistance systems (e.g. ACC, LKAS) (N=6). The mean age of this group is 40.17 years with a standard deviation of 15.55 (age range: 24-58). Every participant had a driver's licence as well as driving experience of a variety of annually driven kilometres.

To recruit participants for the study an invitation was sent to a number of interested participants as well as to colleagues (see appendix). These emails contained general information (time, date and topic) as well as the information on the incentive and a screening questionnaire. This screening questionnaire (see appendix) was used to further categorize the participants to specific user group criteria. Based on the answers of this screening questionnaire the participants were invited to take part in the workshops. Due to cancellation of participants three other participants needed to be invited on short term. These participants did not fit perfectly into the screening criteria (due to no prior experience with driver assistance systems) but were nevertheless invited.

4.3 ***Materials***

A variety of material was applied in the future workshops. Both workshops took place in a large room to assure that for every phase of the workshop enough space would be provided and the room did not need to be changed. The room was equipped with one large table for the first two phases. The participants sat around the table so that everybody could see every participant as well as the moderator and the presentation on a screen/ notice board. The area was also equipped with two extra tables and notice boards for the third phase of the workshop. These areas were enclosed from each other to prevent groups copying from each other. Snacks and drinks were also provided to the participants due to the length of the workshops. The participants were provided with an informed consent and form for their compensation agreement. Furthermore, a guideline of the workshop was provided to every participant so they would know what the workshop includes and when there would be breaks.

Figure 5. Future workshop setting

A power point presentation (see appendix) was used as guideline for the workshop. For each phase slides were prepared that illustrated the main focus of the phase as well as rules and guidelines. The presentation also contained three different videos as the trigger part of the workshop. The first video was a TV commercial that showed what an interaction with a truly fully autonomous car could look like (e.g. sleeping, playing, and eating). This video was used to illustrate the far future and to educate users on possible previous misleading visions towards the concept of automation (compared to the current goal of dynamic shared control). The two other videos were used to provide an impression on intuitive steering and intelligent systems (h-mode) to the participants. One video showed and excerpt of the movie ‘Avatar’ where the horse and the rider connect each other and create a bond between them. This short clip visualized what an intuitive and intelligent system could look like. The other video was also a commercial of a car manufacturer. This commercial showed the transition between a car and driver to a rider and their horse (showing the comparison and interaction between steering wheel and rein). The trigger part also made use of pictures of situations where a possible new system could be applied. These pictures illustrated a highway, traffic in the city, a bend on a rural road with a tractor in front and a zebra crossing. All these scenes illustrated situations and use cases elicited in the diary studies to explain the intention and context of the workshop based on users’ current experience. Moreover, scenarios picked by the stakeholders of the project were applied.

For the first two phases moderation cards were used for the participants to write down their ideas and notes. Depending on the category of the note the participants received different coloured cards (red, green, yellow). These cards where then pinned on two different notice boards.

Due to the creative part in the third phase the participants received a variety of different materials. First, they were presented a prototype of a concept steering wheel including an explanatory video. Then a moodboard was shown which demonstrated future steering concepts as well as future concepts for HMI elements. This moodboard was used to show impressions of future steering concepts to support ideation.

To provide guidance during the prototyping phase also key questions were provided to the participants (see appendix). These key questions were based on the impressions derived from the pre-phase. In order to visualize and apply the concept, different materials were prepared for the participants. Every group was equipped with coloured papers, post-its, pencils, transparencies, tape and scissors. Additionally, a black and white sketch (A3 format) of a car interior (with and without a steering wheel) was provided to them (see figure 6).

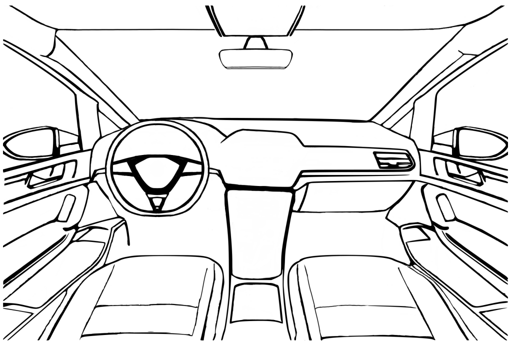

Figure 6. Paper-prototyping sketch

4.4 ***Procedure***

4.4.1 Data collection

There were two workshops that took place at the ErgoLab of Fraunhofer IAO in Stuttgart. This setting provided enough space for the different activities during each phase.
Each workshop began with a welcome and general information. The participants sat down at a table where an informed consent and further information on the rights of the video material was given to them. These forms as well as the form to receive the compensation of 50 Euros for the workshop were signed by each participant.

The workshop began with an introductory phase. The videos and scenarios included in the power point presentation were presented and explained to the participants. The main focus of this phase was put on the trigger part. The essential message for participants was to comprehend the task distribution between the system and the driver. The system only needs input on the drivers' intention (e.g. choose a manoeuvre) that is than completely executed by the automation. The scenarios elicited in the diary study were used to further explain these intentions of manoeuvres. This phase took approximately 30 to 45 minutes.

The phase was followed by a visioning and fantasy phase. Participants were asked to note down their wishes and possible challenges towards a system (based on the description provided in the previous phase). First the moderator asked the participants to present their notes of the green cards (wishes) to the group and give further explanations on their statements. These statements were then clustered on a notice board by another researcher. A third researcher took notes of the statements of the participants and other important impressions made during the phases. After that the participants presented the challenges they saw in relation to a possible future system. These cards were also clustered on the notice board (see figure 7). Participants were then asked to think about scenarios they saw in relation to a future system and also situations where they would like a system to assist them. These cards were also collected on a second notice board. This phase took about one hour. Then a 15-minute break took place.

After the break, the participants were introduced to the implementation phase. First a concept steering wheel was presented to the participants. Then the procedure of the last phase was explained. The participants were asked to create a concept in groups of three persons for steering gestures in relation to the h-mode and manoeuvre based control and to visualize those concepts in paper-prototypes. The group was randomly divided into two subgroups. Then the moodboard was presented for ideation and impressions of other steering concepts. After that the participants were primed to use the key questions. The participants had approximately 45 minutes to create their concepts and prototypes. The researchers observed the groups and guided them if there were any difficulties or discussions. Afterwards each prototype was presented to the group. Then questions were asked to get a more precise impression on their intentions behind the concept. These presentations were filmed for later analysis. The whole workshop lasted approximately 3.5 hours.

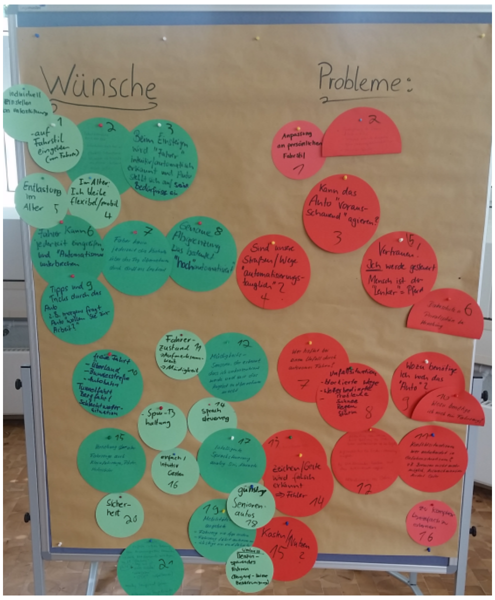

Figure 7. Brainstorming board session one

4.4.2 Data analysis

During the workshops notes were taken about further details and annotations that participants had mentioned on their written information on their cards. These annotations, the cards and the videos which were filmed during the presentation of the concept in the last phase were used as data which was then summarized as follows. All this material was collected and combined so that a full overview of all data was possible. In this collection, the statements of the participants were translated from German to English.

First, all information on the cards from the first and second phase (brainstorming /scenario phase) were collected and translated. Moreover, the extra information of the annotations was included in this collection. The next step was a description of the different videos of each concept. To this description extra information of the prototypes (post-its, description on visualization and paper-prototypes) was added.

These steps provided a collection of all data of every phase of the workshop. To assure that the data was not misinterpreted or any information was missing, two other researchers that had also attended the workshop evaluated the collection to prevent misunderstandings of participants' statements and ensure objectivity. Each researcher added any additional information that was missing in a previous version. Information that was misleading or unclear was discussed with other researchers to rule out misunderstandings. Although questions were asked during the workshops, there were some difficulties understanding some aspects afterwards. These aspects could be solved in discussions with the other researchers. There were two aspects that were excluded from the analysis (unclear statements, statements that were not related to the context (n=2)).

5 Results 'future workshops'

5.1 *General implications*

All three phases of the future workshops were used for further analysis. The focus of the different phases was put on different aspects (wishes/challenges, scenarios/use cases, concepts/prototypes). In every phase, a variety of material was elicited. The first two phases focussed on wishes, challenges as well as scenarios and use cases of a possible new system. The statements could be differentiated based on their context. Five different categories were established to determine the different statements. Beneath an overview of each category is given.

5.1.1 Technical statements

The first category deals with technical statements (see table 2). Technical statements are related to aspects (wishes or challenges) that can be solved based on technical changes or adaptions. Statements that were mentioned in the workshops are related to current state of the art systems or future systems. Aspects related to driver assistance systems such as the lane keeping assistance as well as an ACC were mentioned. Furthermore, concepts of C2X communication or driver state recognition were wished for. In addition, aspects were mentioned that could challenge a future system due to technological interferences. The issue of voice control in combination with radio was addressed but also the challenge to make lanes that are fit for automation.

Table 2. *Technical statements*

Wishes	**group**	**Statements**
	Mass-market	Different driving modes
	Elderly	Environment friendly car (fuel saving: no acceleration uphill)
	Elderly	Lane-keeping
	Elderly	Recognition of driver state (attention, tiredness)
	Elderly	Sensors for tiredness
	Elderly	C2X communication + motorbike, bikes, smaller vehicles
Challenges	**group**	**Statements**
	Mass-market	Limitation due to system acting according to the rules
	Elderly	Lanes should be fit for automation

	Elderly	Radio could interfere with voice control

5.1.2 HMI statements

The second category was related to aspects that dealt with human machine interfaces (HMI) statements (see table 3). Statements regarding adaptability based on different driver personalities/styles were mentioned. Users wished to have a system that adapts to them but also saw challenges if this wish was not fulfilled. Furthermore, safety issues such as who stays in control statements were addressed. Related to that, suggestions were made that focussed on the control of the automation function (turn off/on). Also status information was called for.

Table 3. *HMI statements*

Wishes	**group**	**Statements**
	Mass-market	On/off 'button' for automated functions
	Mass-market	Indication if system wants to intervene
	Mass-market	TOR (take over request) is given with enough time to prepare and get back into the loop
	Elderly	Attending to driving style of driver
	Elderly	Individual adaption of supporting system
	Elderly	Intuitive recognition of driver (already while entering car) -> car adapts to driver’s needs
	Elderly	Tips and tricks ('smart'): car asking in the morning: ‘Are you going to work?'
	Elderly	Driver can interrupt automation at any given time -> via gripping the steering wheel
	Elderly	Car provides option to take over if tiredness is recognized
Challenges	**group**	**Statements**
	Mass-market	Personality of driver (adapting, following rules, driving style)
	Mass-market	Constant attention (if not fully autonomous)
	Mass-market	Who is in control (strict division between driver and car)
	Mass-market	Transition from manual to autonomous and back
	Elderly	Difficult if not adaptable to personal driving style

5.1.3 Steering gesture statements

The third category deals with statements that were specifically related to steering gesture control (see table 4). One important aspect that was reflected by different participants was the wish for simplicity and the related challenge of too complex gestures. This challenge was also related to possible misunderstandings of gestures. Therefore, different ideas were addressed that users wished for. For example, steering via a voice control modality as well as combinations of different gestures or specific gesture 'areas' were mentioned. Similar to the individuality aspect in HMI statements, users also wished for a clear differentiation between gestures of different users. Also, aspects such as learning of gestures were mentioned.

Table 4. *Steering gestures statements*

Wishes	**group**	**Statements**
	Mass-market	Simple steering gestures
	Mass-market	Combination of gestures should be possible
	Mass-market	Gestures should be programmed beforehand
	Elderly	Voice control
		Intelligent voice control (comparable to 'Alexa' or 'Siri')
	Elderly	Simple/intuitive gestures
	Elderly	Fast recognition of gestures
	Elderly	No composited gestures
Challenges	**group**	**Statements**
	Mass-market	Area for gestures (other passengers)
	Mass-market	Individual gestures (depending on driver)
	Mass-market	Left/right handedness
	Mass-market	Plausibility control (gesture might be accidently)
	Mass-market	Misleading gestures
	Mass-market	Misinterpretation of driver intention
	Mass-market	If driver needs to learn too 'much' (learning gestures)
	Mass-market	Clear differentiation between different gestures
	Elderly	Area for gestures (other passengers)
	Elderly	Individual gestures (depending on driver)
	Elderly	Left/right handedness

5.1.4 'Others' statements and scenarios

The last two categories dealt with statements that could not be clearly categorized or were related to scenarios users thought of. General benefits were mentioned such as the possibility to be distracted while driving but also aspects such as mobility of the elderly were addressed. Privacy issues seemed also to be an important issue (regarding data protection). Another aspect that was visible in different statements was related to the 'trust in automation' (e.g., who decides in hazardous situation – 'ethical dilemma'). In addition, a variety of different scenarios was mentioned that can be found beneath.

Table 5. *Scenarios*

General scenarios	Elderly related scenarios	Specific support related to scenario
Construction area	Searching for parking spot	Unclear situations (crossings)
Rain/bad weather conditions/winter	Support when looking over the shoulder	Headwind (lane keeping)
Traffic jam (stop&go)	Night time	
Night time/ darkness	Multilane roundabout	
Overtaking during overland drive		

5.2 *Concepts and paper-prototypes*

The third phase was focussed on the development of a concept by creating a paper-prototype. In every workshop, two concepts were established so in total four different concepts were created. A description of each concept can be found beneath. The concepts 1.1 and 1.2 were developed by the elderly user group. Concepts 2.1 and 2.2 were created by the mass-market user group. Statements related to the three main aspects (HMI, technical, steering gestures) were filtered from each concept to visualize the main points per group. Three of the four concepts were also visualized in a paper-prototype that can be found beneath.

5.2.1 Concept 1.1: 'tilt function'

The first concept dealt with a steering wheel that should be equipped with tilt functions, inspired by gesture control of trains (figure 8). Main functions should be indicated by this modality (above: 'go' -> tilted as long as driver wants to accelerate, beneath: 'stop' as well as 'park', right: 'stop and go', left: 'overtake'). These functions are illustrated to the driver via a small LED on a display based switch. Moreover, a 'click' sound is used for validation to illustrate that a tilt function is chosen.

The concept is based on state of the art assistant functions (e.g. ACC as well as LKAS). Furthermore, the system is intelligent to adapt to the environment, e.g. the system keeps correct distance based on factors such as weather conditions. In addition, the system is able to indicate to the driver which maneuvers are possible in a situation. The driver then only needs to initiate the maneuver by indicating the intention.

During all these actions, the concept bases its control mainly on the driver. That means that the driver has the last decision. The system is not able to act independently, e.g. overtaking without approval of the driver. The concept also applies a function to override the system. If the steering wheel is shaken back and forth in a quick way, all automated functions are stopped. This function was also added to prevent an accidental switching on of the functions, e.g. due to lane conditions.

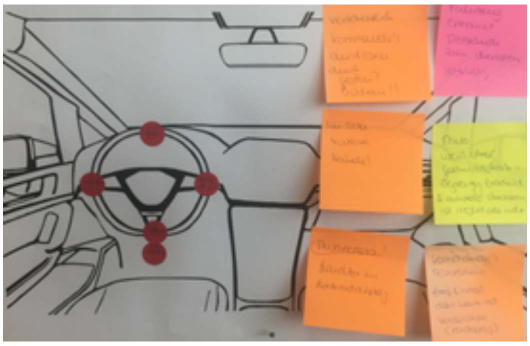

Figure 8. Concept 1.1

Table 6. *Overview of statements concept 1.1*

Technical statements	HMI statements	Steering gestures statements	Others
Steering wheel that can be tilted from four different directions to the back	LED light signals if one tilt direction is recognized	Gesture control medium should be able to recognize dry hands	Main control functions should stay the same as they are now
Current state of the art assistance systems should be		Validation of gesture via 'clicking' sound	

implemented as a base	
	Four main gestures on steering wheel (go, stop and go, stop, overtake)

5.2.2 Concept 1.2: ‘click and talk’

The 'click and talk' concept is focused on a variety of different modalities (figure 9). The goal of the system is to be intuitive to adapt to different kinds of users. The system can be handled via different control options. For example, voice control can be used with different command options (e.g. 'stop'). When the command has been executed the system replies with 'completed'. Furthermore, an option to avoid misunderstandings is provided. Via clicking on display controls and holding on to them (not only touching - real haptic feedback) the voice command can be executed. The voice control system equals an intelligent system that is able to learn (e.g. different dialects).

Another modality that can be applied is a thimble/ring control. In combination with a head up display (HUD), a gesture control is possible. The HUD provides information on different maneuvers. This is visualized via a kind of augmented reality (e.g. trajectory arrows on HUD). Furthermore, the HUD illustrates additional information such as speed and speed limits. By using the thimble (connected via Bluetooth) a maneuver can be selected by pointing at the HUD. Also, an option for disabled users is applied (deaf users) via a camera that can interpret and recognize sign language.

To be able to override automated functions the display click controls can be used. By using one click on both controls, the driver gives the control over to the system. Two clicks signal the transition of control back to the driver again. In general, the system should be as intuitive and simple as possible and the user should not be forced to learn too much to handle the system.

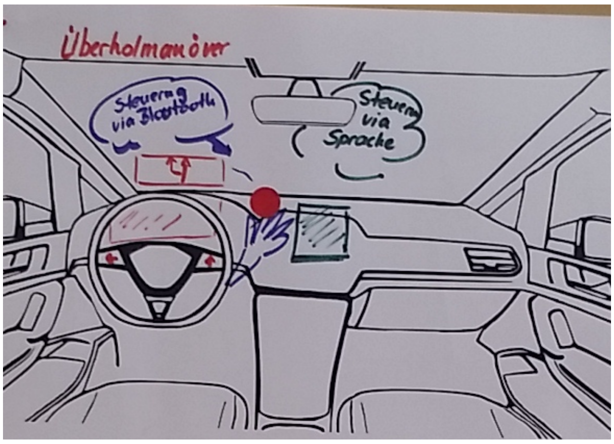

Figure 9. Concept 1.2

Table 7. *Overview statements concept 1.2*

Technical statements	HMI statements	Steering gestures statements
Implement display click control	System should be adaptable to different styles of usage/users	System should provide different options to steer (voice, thimble, display controls)
Head up display	General system information (e.g. speed) should be provided in the information panel	A combination of different gestures should be applied to prevent misunderstandings
Voice recognition	HUD should illustrate trajectory (arrows) as well as list of voice commands	No swipe gestures should be applied
	Feedback if command has been executed (voice stating 'completed')	Simple and intuitive gestures -> no need to specially learn handling
	Repetition of voice command to prevent misinterpretation	Display control should provide resistance if pressed
		Gesture combination of thimble control on HUD
		Gesture combination of click control displays on steering wheel and voice control with commands illustrate as a list on the HUD
		Voice control (intelligent system

	that can learn e.g. dialect)

5.2.3 Concept 2.1: ‘highly automated’

This concept is focused on a high reliance on the automated functions. Most steering functions are taken over by the destination given to the navigation system. The driver can choose between different general routes (as fast as possible, economical). The goal for the system is to be simple. Everyone should be able to drive the car even if they are used to driving another type of car. The system is able to execute everything on its own and if something is unclear, the system can ask the driver (e.g. 'initiate overtaking?'). If the system needs additional information of the driver or the driver requires information from the system, voice control can be used but only on demand. The information that is provided by the system should be as limited as possible to prohibit an 'overflow of information'.

If steering gestures are applied, they should be based on modalities already existing. For example, for overtaking the column switch can be used (e.g. active lane change assistant). If the column switch is moved completely in one direction, it indicates the command 'turn'. Moreover, a combination of current modalities can be used (column switch + gas pedal = signal intention of faster overtaking). To indicate which maneuvers are currently possible the system provides options to select a possible maneuver from. For example, a blinker arrow in the display panel lights up in blue to show that it is possible to overtake. This option can then be selected via 'yes/no'.

To assure that the gestures have been understood correctly, one hand needs to touch or be in contact with the control (e.g. steering wheel). Only then the gesture for giving control to the automation can be interpreted. The system can also be overridden via a button that controls the automated functions. If the button is pressed, the system can be enabled and disabled. If both hands (including thumbs) are detected on the steering wheel the 'autopilot' function is also activated but only on straight lanes (e.g. highway). In order to illustrate that, the automated functions are activated, LEDs on the steering wheel are used. If the LEDs light up in green the system indicates to the driver that the 'autopilot' mode is activated. If the lights turn red the system signals a hazardous situation (driver needs to take over).

The system is furthermore equipped with additional functions. For example, C2X communication is used to provide the driver with information on accidents, environmental conditions (e.g. ice on lanes) and with information that facilitates a comfortable drive (system knows that driver smokes so it gives information on resting areas). The instrument panel provides information via text message that a maneuver will be executed. The concept also offers the possibility of HUD/projection to the front shield (showing symbols).

Table 8. *Overview statements concept 2.1*

Technical statements:	HMI statements:	Steering gestures:	Others:
C2X communication	Button that enables/disables system	Voice control	Everyone should be able to drive car (even when not trained)
Sensors should state if they are 'ready'	Central display: via text message if maneuver is going to be executed	Longer gestures (e.g. column switch) indicate different intentions (overtaking/turn)	
	HUD with additional symbols	Combination of different control parts (gas pedal + blinker switch)	
	Blinker arrow in display lights up blue to show it is possible to overtake	Intuitive with no additional functions (based on current state of the art)	
	No need for information that commando has been correctly executed	Gesture is only executed if one hand is on steering wheel to prevent misunderstandings	
	Amount of information as limited as possible	Options (light up of blinker arrow) can be selected with yes/no	
	Any additional information of driver/system are only provided on demand (voice controlled)		

	LED lights on steering wheel that visualize current status (green: autopilot, red: hazardous situation)	

5.2.4 Concept 2.2: ‘combining different modalities’

This concept makes use of current modalities as well as adding new modalities (figure 10). These different modalities are used in a combination to indicate a steering gesture. A HUD illustrates the trajectories including the option that is locked. There is no text shown on HUD, only trajectories via arrows. A preselection of different maneuvers and recommendations based on the current traffic situation and the destination is shown on the HUD. The most suitable option is preselected and only needs to be confirmed by the driver via a 3D Joystick.

The modality of a 3D Joystick which is similar to a multimodal rotary button is added in the center console (between driver and passenger). The rotation sensitivity is adapted to the context. This secondary input device functions as a central steering input element. It only provides as many options as currently possible (equal to rotary options). During long haul rides the hands do not need to be on the steering wheel and the 3D joystick can provide more comfort. If an option is chosen, the joystick provides haptic feedback via a vibration. Furthermore, the safety function of a fingerprint sensor is added to assure that only the driver can control the system. This function prevents misunderstandings and accidental operations (e.g. children playing with 3D joystick).

Another input device is the steering wheel. The steering wheel can be used to actively delegate tasks to the system. The steering wheel as well as the brake are always superior compared to other modalities. These modalities are used to override automated system functions. When both hands are detected on the steering wheel, the system can be overridden and it gives the control back to driver. Additionally, an active counteraction on the steering wheel provides the possibility to override and change intention.

An LED-band around the windshield is used to indicate the system status to the driver. If the LEDs turn red, a hazardous situation is detected in which the system is not able to take over. The command needs to be stopped and the driver needs to take over. If the LEDs turn yellow, the system indicates that a command is currently executed or will be executed as soon as the traffic situation is suitable (overtaking). Green LEDs indicate that the system is ready for regular driving mode and that a command can be executed instantly. Moreover, green LEDs in the lower half of the steering wheel light up when the 'autopilot' mode is activated.

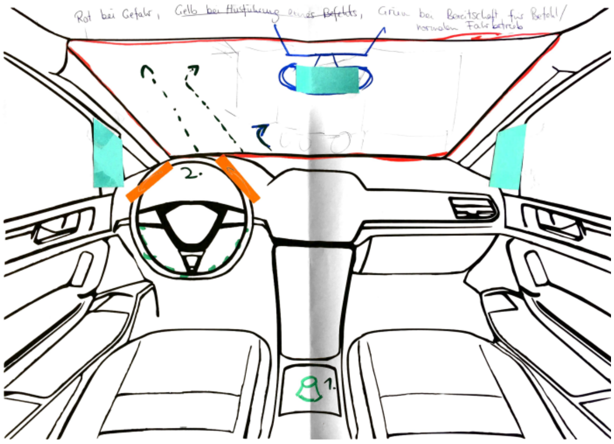

Figure 10. Concept 2.2

Table 9. *Overview statements concept 2.2*

Technical statements:	HMI statements:	Steering gestures:
Capacitive steering wheel	HUD with trajectory and preselection	Second input device (3D-Joystick with specific functions): fingerprint sensor, only tilting options as currently possible, vibration as feedback
Displays in mirrors (rearview as well as side view mirrors)	LED strip around windshield red, yellow, green) to communicate current status of system	Gestures directly over steering wheel swipe to finally execute maneuver
	LED strip on lower half of steering wheel	
	Only visual information no text based information	
	Steering wheel/break to override	

6 Discussion

Taking the user into account throughout the whole design lifecycle is an essential part of Requirements Engineering (RE) (Vavoula et al., n.d.). Otherwise, the design would not fit the users' visions and lead to difficulties in using the products (Robertson, 2001). Therefore, in the beginning of a design lifecycle, requirements elicitation is an important step that takes users' opinions into consideration and focusses on their wishes. The area of RE offers a broad spectrum to elicit user requirements for different contexts. However, when it comes to the context of innovative technology, there seems to be a gap. According to Robertson (2001), the user needs to be encouraged to actively imagine an 'undreamed' requirement. Vavoula & Sharples (2007) go a step further and state that the users need to be actively engaged to be able to develop requirements. But according to Inkpen (n.d.) the users are restricted by their current experiences and therefore, limited when imagining the future. A bridging between the current experiences is needed toward the innovative future vision. The difficulty arises how to let the user engage and experience a future they have not even thought of in a context that does not even exist. Thus, the challenge of how to extract user requirements from dreams evolves (Boehner et al., n.d.). Therefore, the research question was established how user requirements can be elicited in an innovative future oriented context.

Based on the research question, an evaluation of different elicitation techniques was performed judged by criteria related to the context. Afterwards the most suitable techniques were combined and adapted. A pre-phase and iterations were included in the process till the final version of the future workshop was carried out. The results acquired during the workshop elucidate that this focus on the users' perspective is a prominent aspect. In general, the results were based on steering gestures that focussed on a cooperative interaction with the system. During the visioning and fantasy phase the participants developed possible wishes and requirements they would have towards a future system, but also reflected on challenges that could be related to the system. In addition, a variety of scenarios in which the participants would wish a system to assist them were given. In the last phase four different concepts were established that each presented an individual vision of steering gestures focused on a cooperative interaction.

The elicited results will now be applied to further evaluate and discuss the developed method. Therefore, different relevant aspects are chosen to delimit the discussion to main relevant points. Moreover, parts of the criteria to judge the variety of methods (see section 2.2.) are used for evaluation due to their direct connection and reference to the challenges found in literature as well as the scope and context of the case study. By applying these criteria, the main discussion aspects seemed to be productivity and innovativity that is used to evaluate the effectiveness of the method by comparing the elicited results in relation to the innovative future oriented context (see section 6.1). Another aspect seemed to be the issue of the cost-effectiveness trade off. If the method will be applied in future studies, the benefits regarding the effectiveness of the method compared to the costs should be thoroughly analysed to be able to decide if it is worth the expenditure (see section 6.2). Downstream utility seems also to be an important aspect to judge if the resolved results can be applied further on in the process (see section 6.3). This seems to be essential due to the otherwise uselessness of the developed method that would then no longer be efficient at all. Connected to this discussion, a prospect view on how to integrate the results in the design lifecycle should also be given (see section 6.4). Besides, related visions and approaches need to be discussed to place the method and compare main aspects to be able to further improve the scope of the method by a possible combination with another relevant approach (see section 6.5). Moreover, aspects such as dependability and credibility should be checked to assure that the method can also be applied in other contexts (see section 6.6). At last, weaknesses and disadvantages should be evaluated to propose improvements for future studies (see section 6.7). All these evaluation aspects are relevant to be able to complete the picture related to the research question of the developed method and to place it in the field of RE.

6.1 *Productivity and Innovativity – Evaluation on effectiveness of the developed method*

The results presented in the section (*5.0 - Results*) above visualize the productivity of the workshop. A variety of ideas containing different user needs and visions were elicited. The goal of this study was not only to elicit user needs, but also to establish innovative ideas in a future oriented context. So, how innovative are these major ideas and visions created by the user groups? The question arises how creative and innovative this productivity can be seen. The idea of implementing a voice control system (related to click and talk concept) can also be detected in intelligent systems such as 'Siri' and 'Alexa'. These systems were also stated by the participants directly as their source for ideation; similar to the tilt function based on steering a train, and the 3D-joystick based on a 3D (multimodal) space mouse as well as the thimble modality based on input device for virtual reality. All these ideas were not completely innovative and new. Ideas such as the active lane changing assistant are already implemented, for example by Daimler (Hiesgen, n.d.). Moreover, concepts concerning voice control for managing comfort functions exist (Schalk, Saenz, & Burch, 2017). It can be argued that the ideas are therefore not innovative but the transfer to a new usage context can be seen as the creative and innovative effort. Applying these ideas to a new spectrum (from the context of using a 3D mouse for a computer to transferring this gadget to another context of a highly automated car) proves that participants used their current experiences and related them to future systems (Inkpen, n.d.). This was stated as a demand for creating innovative requirements for a future oriented context in the beginning and can now be clearly observed (Inkpen, n.d.). This transfer can clearly be detected in the ideas elicited. At first sight the creative and productive ideas seem to be not completely new and therefore maybe not innovative enough, the transfer to the used context however, makes the effort to rate these ideas innovative.

6.2 *Cost-Effectiveness trade off – Evaluation of scope of method*

The criteria that were used to develop and choose the most suitable method also focussed on aspects of cost and effectiveness such as 'accessible resources' and 'minimal participant training'. Therefore, it seems only logical to further evaluate this criterion for future research. Although holding the future workshops was time efficient - it took approximately eight hours for two workshops - the preparation including the pre-studies were time consuming. If applied to other areas and design questions, most of the preparation needs to be redone. Although the iterations were used to develop and further improve the method in general, important contextual aspects were acquired that were used in the later on studies (e.g. key questions and scenarios). The pre-studies are an essential part of the future workshops and need to be included. Based on these pre-studies, it was possible to line up a suitable space that offered users the opportunity to develop ideas that implemented the main goal and direction of the study and leave room to stay innovative and let the users be creative. The pre-phase made the process extensive and therefore enlarged the costs but compared to their relevance still seems to be essential and necessary to be able to hold effective future workshops.

The development of the material might slightly change depending on the context (e.g. steering wheel zone study explicitly used for the project context, diary study focussed on highly automated driving context). Still the approach can be transferred to other future oriented contexts that focus on innovativeness. Reusing the method in a different context might cost time for preparation, but as argued above, this preparation is essential to provide an interaction that is based on the participants' level. Moreover, this process balances the discrepancy between 'efficiency' boundaries and innovativeness/effectiveness and should not be disregarded.

According to Boehm (2001) it is important to detect and eliminate errors in the process as early as possible. Based on the exponential cost curve developed by Boehm, an error that is only detected after the process has already evolved, gets exponentially more expensive (Boehm, 2001). The pre-phase might seem extensive (e.g. preparation, iterations) related to higher costs. However, compared to limiting the requirements phase and therefore detecting errors not until later on in the process, the costs could be much higher. Taking Boehm's curve into consideration, a pre-phase in addition to the workshops might first seem too extensive, but could later on reveal to be the most efficient option. Therefore, the extensive pre-phase can be justified and forms one of the core phases of this process.

6.3 *'Downstream utility' - How to analyse and specify a diverse and contradictory vision?*

To justify the need for the extensive user-centered approach, such as pre-studies and workshops, the downstream utility of the information acquired should be considered. This implies that the results need to be evaluated based on their usefulness and applicability in the whole design lifecycle (Law, Lárusdóttir, & Norgaard, 2007; Law, Roto, & Hassenzahl, 2009). If the results cannot be further considered due to impracticability, the general utility of the process can no longer be defended. Therefore, a form is needed to analyze and specify the results in such a way that is applicable for the whole lifecycle. For example, statements such as 'simple gestures' can function as aspects in an evaluation catalogue that can be used during the different steps in the lifecycle to keep the design user-centered (Bourque & Fairley, 2014). However, the question still arises how to measure when a gesture can be rated as simple. It gets even more complex when trying to integrate specific design aspects of the concepts into the lifecycle.

The results acquired in this study could be divided into four different categories (general/technical, HMI, steering gestures, scenarios/others). Compared to the results acquired in the prototyping phase, the statements acquired in the first stages are on a more superior and general level (e.g. simple gestures). During the second phase participants mentioned similar wishes and challenges that were directed towards the same trend and were mentioned by almost every participant. For example, statements such as intuitive, simple, no complex gestures or misunderstandings regarding gestures all pointed at a general/superior description of the category. These general implications can be resolved from this phase that can then function as requirements. These implications might be useful during the beginning stage to understand users' visions towards the topic, but they do only partly assist the designing process.

Considering these results, it might be possible to conclude that the method is able to elicit user requirements for the future oriented context. However, the question still arises how these 'requirements' are innovative if they only visualize users' concerns and wishes on a superior/general level. The results that were acquired during the prototyping phase dealt with detailed specification of a possible concept. These concepts provided a more in-depth level of user wishes and visions. Moreover, the ideas in the concepts were not only oriented towards a possible future system but also presented their innovative vision of their concept. It seems that these concepts make up a suitable fit to function as requirements that are future oriented as well as innovative. Nevertheless, each concept provided an individual vision that partly and/or completely contradicted ideas of other concepts. For example, the 'click and talk' concept added a voice control modality to their concept which was completely out of discussion for the 'tilt function' concept. Stating both visions as requirements would not be logical and contradictory. Difficulties regarding which requirement to give more priority (or which requirement to eliminate) would evolve during further development. If the decision between two contradictory visions does not evolve directly from the user group, the design would no longer be user-centred. This would make the whole workshop obsolete. Of course, possible requirements on a superior level could be extracted from these concepts. For example, every group used a combination of different modalities. This result could be used as a 'requirement' (a combination of different modalities should be implemented). However, disregarding the innovative ideas developed in the concept would lead to failing the main goal of this study. Most innovativeness (e.g. 3D-joystick) lies within these detailed specifications of the different concepts.

As described in the introduction, now the possible challenge of 'analysis' as well as 'specification' in RE comes true. Beforehand it was not clear if there are challenges that are connected to continuing processes for eliciting requirements for future innovative technologies. If it was possible, and innovative requirements were elicited, the question would arise how to cope with contradictory visions of concepts that visualize innovativeness. Completely disregarding the ideas would ignore the goal of eliciting requirements directed towards innovativeness.

6.4 *Techniques to integrate results in the design lifecycle – 'Design Space' and 'Personas'*

Based on the challenges in the section before, the question arises how should one deal with statements and visons that constitute the complete opposite of each other? A design space could provide a suitable option (Ballagas, 2008). According to Rasmussen, Pedersen, & Petersen (2012) a 'space of possibilities' can provide an objective structure to the different subjective visions. The statements that were elicited in the concepts could be defined and specified as parallel directions that visualize different design dimensions. These parallel directions could display the variety of different positions. In a further development, these spaces could be evaluated and tested (Card, Mackinlay, & Robertson, 1990; Gajos, Czerwinski, Tan, & Weld, 2006). According to Sengers & Gaver (2006) co-existing competitive interpretations can be fruitful and useful in the process. These competitive interpretations could be visualized in a mind net map (Flemisch, Schindler, Kelsch, Schieben, & Damböck, n.d.). This mind net map can function as a creativity tool that enables the exploration of the developed visions, but also offers to explore new combinations (e.g. combination of different modalities of different concepts).

For example, different spaces representing different ideas (e.g. voice control and 3D Joystick) could be elaborated in different prototypes. Users could then directly engage in the technology and develop a realistic experience. According to Adell (2009) and Arndt (2011) users are only able to fathom and grasp something if they have the possibility to directly experience it. This direct engagement might reveal positions and attitudes of users that are only derived by experience. Users might for example realize that the option (e.g. voice control) is not that desirable anymore and change their wishes due to this direct engagement and experience. Therefore, it is essential to incorporate not only the general requirements but also elaborate on specific innovative ideas that might be contradicting but still can be prominent in further evaluation. The design space could impose an approach to cope with these opposites. Innovative contradicting aspects should not be disregarded when they do not fit the traditional vision. The form and approach should also be adapted to the users, never the other way around (Norman, 2013). Only then a user centred approach is granted.

The method of personas could also provide a suitable fit for the diverse results. In general personas support the lifecycle by identifying and understanding the target audience. This can promote development and design decisions that need to be made in the lifecycle (Pruitt & Grudin, 2003). According to Pruitt & Grudin (2003) personas can serve as medium for communication. If used in combination with other methods personas can complement these methods as well as amplify the effectiveness of other methods. Not only are these arguments cogent, but the method also offers the option to develop a variety of different perspectives for different personas (Acuña, Castro, & Juristo, 2012). For example, one persona could be developed that is based on ideas derived from one concept (e.g. click and talk). This persona could then stand for this vision including the different needs and wishes that were stated regarding the concept. Another persona could then stand for another concept. Using this method to specify and analyze the acquired data could solve the contradictory demands that created a 'wicked' dilemma (Peter, 2015).

6.5 *Variance in user visions – Applying the approach of design thinking*

Another question that arises is how these contradictory perspectives described in the section before could develop. In total there were four groups during the last phases of the workshops with three participants in each group. The groups were randomly selected. Some groups maintained similar visions for a future concept (e.g. click and talk). These groups can be described as homogenous due to their similar visons (Good & Marshall, 1997). In comparison to other groups these groups were able to work more efficiently regarding the time limits that they were given. Most of the time they followed three steps: discussing their ideas, forming a concept, realizing the concept with paper prototypes. Other groups that were composited out of conflicting visions remained in a discussion about their different opinions. Therefore, these groups collided with the given time limits and were not able to produce a paper-prototype reflecting their ideas. The consequence could be derived that groups should be formed based on similar vision. But this would result in homogenous groups that are not equipped with different positions.

The design thinking approach sates that 'divergent thinking is the route, not the obstacle, to innovation' (Brown & Wyatt, 2010, p.34). Transferring this approach to the current consideration, it seems to be essential to work with heterogeneous groups to encourage innovativeness. According to Brown (2009) divergent thinking can be reached by a multidisciplinary group with members who are diverse. These people have the capacity to be innovative in collaboration. This would then mean that heterogeneous groups have the power of being innovative due to divergent thinking. But how to cope with ongoing discussions of divergent groups while being restricted by time limits and still focussing on the goal to create a concept and prototype. According to Brown & Wyatt (2010) first a variety of visons is needed to form a good idea. This variety of ideas and choices stands for more complexity that can lead to difficulties. However, restricting these ideas at the expense of efficiency will result in conservative perspectives and inflexibility in the long-run (Brown & Wyatt, 2010). Therefore, a strategy needs to be found that integrates the opportunity for discussion between diverse user groups while also being efficient. Further research can be directed to evaluate options to fulfil the requirements of both directions (see section 6.4).

For future research, the workshop could be focused on the last phase. By applying only the last phase of the workshop, more time could be granted for generating a diversity of ideas as well as maybe also being able to transform these ideas into a concept and prototype. According to the design thinking approach participants would then have enough time available to discuss their different visions. But similar to the developed method in this study the design thinking evolves through three different stages (Brown, 2009). The three steps 'inspiration', 'ideation' and 'implementation' are comparable to the steps applied in the workshops. The inspiration stage can be compared to the introduction phase containing the trigger part. In both processes users were introduced to the topic. During the ideation stage and the visioning/fantasy phase users are asked to think about the topic in more detail. Also, the implementation stage and prototyping phase have similarities. Both processes focus on a realization of the ideas and visions developed beforehand (Brown, 2009). If the stages used in the design thinking process are similar to those used in the future workshop and the approach of design thinking has as main standpoint being innovative, the workshop should not be shortened or limited to one phase. Although creative aspects such as prototyping are able to accelerate innovation and the use of visual representations of the concepts supports participants grasping complex ideas, preparatory phase/stages are still needed (Brown & Wyatt, 2010). Without any inspiration or ideation an implementation of the stages before is impossible.

6.6 *Credibility/Dependability - Can the developed method be used for other studies?*

For further usage of the results acquired and also for further studies applying this method the validity of the method needs to be evaluated. Due to the open-ended focus of the method, there was no controlled process possible. This makes the criterion of dependability difficult to achieve. If transferred to another usage context or even to another participants group, the transferability of the method cannot longer be granted (Golafshani, 2003). Strategies such as ‘thick descriptions’ can be applied to evaluate the transferability and dependability of the developed method (Geertz, 1973). The strategy relates to variations in behavior in different contexts. Based on the constellations of the future workshop groups, a variety of ideas were developed. Because of these different constellations, it was not sure how people were influenced and maybe also inspired by each other's visons. The context of the workshops might have also influenced their behavior. If the constellations of the groups had varied, the discussions and developed ideas could have been different. That means that the strategy of thick description might have an influence on the transferability (Geertz, 1973).

But this variety of ideas seemed to be the basis of fruitful innovative concepts. Limiting this process to accomplish an independent process would be counterproductive. Based on the constellations and participants, completely new concepts and vision could evolve. Therefore, the credibility of the results might be limited to specific participants. However, general ideas and needs pointed at the same trend (e.g. simple steering gestures). But it might be that due to the focus of this study, this issue can be disregarded. The method holds to explore a possible design space based on users' vision. The main goal might then not be to develop requirements that fulfill the criteria of dependability and credibility. This should always be kept in mind when applying this method in other studies.

6.7 ***Future research – Adaptions for further improvement***

In addition to what has been already stated and described above, further research is needed that develops and evaluates an adaption of the method which considers the ideas of the design thinking approach. Based on the weakness related to the developed method, improvements and adaptions could be applied. One example therefore is the difficulty of matching the efficiency-effectiveness trade-off. A balance between the efficiency-effectiveness trade-off needs to be developed that incorporates and applies the ideas and advantages of diverse groups while also implementing some kind of structure to keep the process focussed. An example could be to divide the last phase of the workshop into three separate phases. These phases could equal the three steps of the design thinking process (Brown & Wyatt, 2010). First an inspiration phase could be held for the participants to discuss their ideas of a concept and use the moodboard as well as their exchange of ideas to inspire each other. In the following step (ideation) the participants are able to establish their concept based on the previous phase. During the last step (implementation) the groups could convert their concepts and ideas into a prototype. Using these steps could give the last phase of the workshop a more distinct direction. Still this structure could also restrict the participants and limit their freedom to create innovative ideas. Future studies could adapt this structure to evaluate the utility. It could be that a larger timeframe of the workshop is needed to implement this adaption in an effective way.

Another issue for future studies is the context the method is used for. One weakness of this study was related to the restricted context the method was used and evaluated in. Of course, the context of highly automated driving seems to be prevailing but other contexts might differ and therefore limit the scope of the evaluation to this specific context. It might be that depending on the project context, a different balance is required. Depending on the goal of the project and the framework given by the context, a more open-ended perspective or a more restricted vision can be implemented. This can be regulated by modifying the trigger phase and the provided information. Still this should be thoroughly considered beforehand in order not to restrict and limit the participants too much. Therefore, the method should be applied in different contexts to evaluate how different contexts and trigger parts influence the process and the product. Besides, one workshop could be held that provides a completely open-ended trigger part to the participants (e.g. only stating the main question/aim of study). These results could then be compared to a workshop that applies a specific trigger part that deliberately directs participants in one direction (e.g. present voice control options for steering gestures). But it should be always kept in mind that by restricting this process and/or priming the participants, the later on development can be inflexible and too conservative (Brown, 2009). As innovation for a future context is the main goal, a conservative view would be counterproductive.

6.8 *Conclusion and outlook*

In general, it can be concluded that the goal to establish a method that elicits user requirements in an innovative future oriented context was partly reached. General requirements could be elicited that where directed towards a future context, but innovative ideas contradicted and did not fit the traditional perspective of user requirements. Other approaches such as a design space are needed to relate users' ideas and statements to a fitting format. Moreover, further research is needed that evaluates adaptions to the prototyping phase. Although, heterogeneous groups seemed to be not efficient (due to limited time) regarding the goal of prototyping a concept, the diversity of groups still is essential to create innovativeness (Brown & Wyatt, 2010). Therefore, an adapted version of the last phase is needed while still using the other phases that form a base for the later on implementation. The first two phases seemed to work sufficiently in this context. Still there is the issue of the need for adaption when applied in different contexts. The preparation for the trigger part and also the general user centred perspective is time consuming but essential and should not be disregarded. The method seemed to be applicable for the context it was used in, but should also be tested for different innovative directions. To sum up, the developed method worked and can probably be adapted to a wider class of future-oriented design projects. Major improvements can possibly be reached by a recombination with other UX methods, such as personas and design thinking.

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Appendix

7 Appendix A: Description 'pre-phase' studies

7.1 *Pilot diary study*

7.1.1 Design

In this study, the experience sampling method was introduced. An event sampling in a diary format was completed by all participants.

7.1.2 Participants

Three participants took part in the study. Two female participants and one male participant completed the study. The age ranged from 20 to 27 (M=25; SD=3.37). Every participant was in possession of their own car and drove this car on a regular basis.

7.1.3 Materials

Each participant receives a booklet. This booklet contains 15 copies of a predesigned form. The predesigned form contains different questions that need to be filled out as well as open-ended questions on their experience used for further evaluation. One section deals with basic information questions on each trip (date, time, starting point, destination, car-type, passenger including a bird's eye view illustration to indicate their position). The following section deals with experiences of the ride (SAM-scale for measuring emotions). The last question provides a timeline from A to B which can be used to visualize main events during the trip (including their time and length). The diary form ends with a question to further evaluate and let the participant think about possible support options (open-ended question).

7.1.4 Procedure

7.1.4.1 Data collection

The focus of this study is to research which driving related situations/tasks are currently difficult for drivers. The participants are asked to collect their experience (scenarios, use cases) with their current systems (e.g. assistance systems) and think about situations which need support from a newly developed system.

The experience sampling method of a diary study is applied. With a diary study the users collect their experience with different rides and are able to evaluate these rides. The system to be developed will be used in advanced cars. Therefore, the user group should stem from the mass-market. The users should be technically affine and already have experience with driver assistance systems. These users are the customers who are interested in buying such a system later on and are therefore the targeted group. Furthermore, the participants should have their own car and use this car regularly (otherwise the diary study could not be completed effectively). Based on these criteria the participants were selected.

The chosen design sampling protocol is an event based study that lasts approximately one to two weeks (depending on the frequency of rides). The paper pencil form is used as a platform. This platform provides a cost-efficient method and can be filled out and carried around the car easily. The participants are personally introduced to the usage of the booklet. Afterwards the participants receive the booklet and are asked to fill in one form after each ride.

7.1.4.2 Data analysis

The diaries are collected from each participant. The material is examined and main pin points are noted down that seem to be relevant to further discuss with the other researchers. These pin points are based on relevance to the project (steering gestures, difficult scenarios, wishes and requirements to future systems). Based on the given data conclusions are made to further improve the study and the attached material. Aspects that are not answered as intended are evaluated for further improvement. Furthermore, participants are asked for feedback on their experience with the study. These aspects are also used for evaluation.

7.1.5 Results

In general, the diary booklets were filled out sufficiently. Every participant filled in at least five forms. Based on the feedback given by the participants, the study needed to be improved in specific aspects. For example, the question regarding information on passengers in the car was not always filled in. Furthermore, participants mentioned issues filling out the SAM scale. The illustrations were difficult for them to interpret. Participants mentioned that the meaning of the illustrations were not clear to them. Another difficulty arose with the timeline that had not always been filled in. Participants had issues combining the given instructions with the sketched timeline. Based on the superficial way of the given answers on the last question it was thought of to further determine the intention of the question. The formulation of the question containing the expression ‘automation’ was not specific enough regarding the context of the project.

7.1.6 Conclusion

Based on the results and feedback, conclusions were derived to enhance the study. Many difficulties were related to the fact that participants had issues understanding the intention of questions. For example, the passenger question was not defined clearly enough. Also, the illustration of the timeline was not distinct enough. Therefore, it was decided to add a form with filled in example. This form supports people and clarifies the intention of each part.

To further guide the participant additional examples can be added to the questions directly (e.g. internal problems: crying baby). Also, a further definition on an expression can be given to elucidate the intended context of the question at hand. By doing this, difficult and vague expressions could be made more explicit for users to grasp (e.g. automation). Another aspect that was criticized was the unclear illustration of the SAM scale. In spite of this criticism the SAM scale cannot be changed because of its high validity and frequent appliance (Bargas-Avila & Hornbæk, 2011; Law, Roto, & Hassenzahl, 2009). Another option needs to be established to support the participants filling in the scale.

7.2 *Diary study*

7.2.1 Design

In this study, the experience sampling method was introduced. An event sampling in a diary format was completed by all participants.

7.2.2 Participants

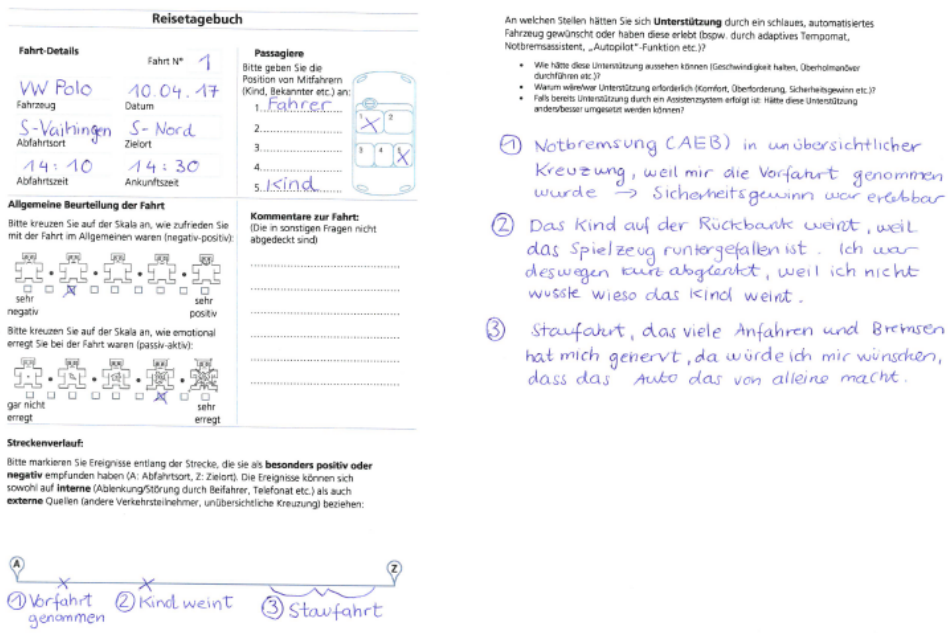
Three participants took part in the study. Two male participants completed the study. The age ranged from 27 till 35. Every participant was in possession of an own car and drove this car on regular bases. Furthermore, the participants were selected on basis of their sufficient experience with driver assistance systems.

7.2.3 Materials

Based on the booklet used in the pilot study an adapted version was applied in this study. An introduction was added to the booklet to give the participants an insight on the context and prime them in the direction of the h-mode. The introduction/instruction (see appendix B) gives a general overview on the topic (h-mode, maneuvers, highly automated driving). In addition, a short note (summarizing the introduction) was added to remind the participants of what the main goal of this diary was. This supported the participants if they needed information on the context during the study and were not able to contact the researcher. An example of the filled in form is shown in figure 1.

Furthermore, a form with a filled in example is provided in the booklet. This example should help the participant to fill in the form in the required way. Also, it conveys an idea of how a ride can be visualized on the timeline or how the passenger question is correctly filled out. Based on the pilot study these seemed to be problematic issues.

The SAM scale was still applied but slightly adapted due to the participants expressing their concerns about the clarity of the illustrations. Additional expressions on both ends of the scales were added to assure that participants would understand the implications behind the illustrations.



Reisetagebuch

Fahrt-Details

Fahrt N° 1

VW Polo
Fahrzeug

10.04.17
Datum

S-Vaihingen
Abfahrtsort

S-Nord
Zielort

14:10
Abfahrtszeit

14:30
Ankunftszeit

Passagiere

Bitte geben Sie die Position von Mitfahrern (Kind, Bekannter etc.) an:

1. Fahrer
2. ....
3. ....
4. ....
5. Kind

Allgemeine Beurteilung der Fahrt

Bitte kreuzen Sie auf der Skala an, wie zufrieden Sie mit der Fahrt im Allgemeinen waren (negativ-positiv):

sehr negativ — sehr positiv

Bitte kreuzen Sie auf der Skala an, wie emotional erregt Sie bei der Fahrt waren (passiv-aktiv):

gar nicht erregt — sehr erregt

Kommentare zur Fahrt:
(Die in sonstigen Fragen nicht abgedeckt sind)

Streckenverlauf:

Bitte markieren Sie Ereignisse entlang der Strecke, die sie als **besonders positiv oder negativ** empfunden haben (A: Abfahrtsort, Z: Zielort). Die Ereignisse können sich sowohl auf **interne** (Ablenkung/Störung durch Beifahrer, Telefonat etc.) als auch **externe** Quellen (andere Verkehrsteilnehmer, unübersichtliche Kreuzung) beziehen:

A ... Z

① Vorfahrt genommen ② Kind weint ③ Staufahrt

An welchen Stellen hätten Sie sich **Unterstützung** durch ein schlaues, automatisiertes Fahrzeug gewünscht oder haben diese erlebt (bspw. durch adaptives Tempomat, Notbremsassistent, „Autopilot"-Funktion etc.)?

- Wie hätte diese Unterstützung aussehen können (Geschwindigkeit halten, Überholmanöver durchführen etc.)?
- Warum wäre/war Unterstützung erforderlich (Komfort, Überforderung, Sicherheitsgewinn etc.)?
- Falls bereits Unterstützung durch ein Assistenzsystem erfolgt ist: Hätte diese Unterstützung anders/besser umgesetzt werden können?

① Notbremsung (AEB) in unübersichtlicher Kreuzung, weil mir die Vorfahrt genommen wurde → Sicherheitsgewinn war erlebbar

② Das Kind auf der Rückbank weint, weil das Spielzeug runtergefallen ist. Ich war deswegen kurz abgelenkt, weil ich nicht wusste wieso das Kind weint.

③ Staufahrt, das viele Anfahren und Bremsen hat mich genervt, da würde ich mir wünschen, dass das Auto das von alleine macht.

Figure 1. Example filled-in diary study

7.2.4 Procedure

7.2.4.1 Data collection

(see section 3.1.4.1)

7.2.4.2 Data analysis

The diaries were collected from each participant. The material was examined and main pin points were noted down that seemed to be relevant for further discussing. These pin points were based on relevance to the project (steering gestures, difficult scenarios, wishes and requirements to future systems).

7.2.5 Results and conclusion

Based on the data elicited in this study and the pilot version, key aspects are filtered to be used in the future workshops. Participants mentioned different assistance systems and 'autopilots' and their experience with these systems. This perspective can be used for visualization of current challenges with automation in the workshop. For example, participants mentioned the wish to avoid negative emotions while driving related to slow ahead vehicles but also vehicles driving too close behind them. Also, traffic jams were mentioned that were annoying for participants and were partly taken over by assistance functions. Also, assistance with maneuvers such as 'overtaking' was mentioned. Other situations were related to lane keeping. Aspects such as concerns with a rescue alley or narrow construction lanes were mentioned. The wish for an HMI was stated.

These different insights that were gained during the studies provide knowledge that can be used if question arise during workshops. This insight might help to stay on the same level as the current user perspective to provide participants with examples that guide them in the intended direction. For example, the elicited scenarios and experiences as well as wishes can be applied in a trigger part of the future workshop. These options might be easier to grasp for participants because they were directly derived from their user group. Complex and abstract expression such as 'maneuvers' or 'highly automated' might be more relatable if explained with elicited scenarios and use cases that users are frequently confronted with.

7.3 *Steering gesture study*

Instructions as well as general implications of the project needed to be tested beforehand. A study was conducted that tried to get insight in the participants' vision of 'steering gestures' as well as trying to evaluate and establish a guideline for questions (for de-briefing of diary study).

7.3.1 Design

In this study a within subject design was employed. The study consisted of one group that fulfilled the same task. The tasks were presented to each participant in the same predetermined order.

7.3.2 Participants

Ten participants took part in the study, five female participants as well as five male participants. The age varied from 24-60. All participants were right handed.

7.3.3 Material

The study took place at a driving simulator (equipped with a camera) at Fraunhofer IAO. In front of the car a canvas was placed which was used to show videos of the different maneuvers. Per maneuver one video was selected that visualized the scenario from the driver's perspective. The videos lasted approximately 15-30 seconds. In total, there were six different videos showing different maneuvers (stopping, starting, changing lanes, right/left turn, zebra crossing). The videos showed real situations that were filmed during actual traffic situations.

7.3.4 Procedure

7.3.4.1 Data collection

First, the participants were introduced to the study and a general overview was given to them on the procedure. Then they were asked to sit down in the car. As the participant sat down, the context of a steering gesture was explained (static steering wheel that only recognizes touch/swiping). Then the first scenario video was shown to them. At the critical point (e.g. shortly before the traffic lights turned green) the video was stopped. The participants were asked to imagine how they would try to initiate the specific maneuver with a steering gesture. First, they were asked to think of the context of manually driving. The second variant was in the context of highly automated driving. In this context, the participants were also asked to think about how to signalize to the automation what option they wanted to choose. The third variant dealt with the context of driving with only one hand. In some situations, there could be the case that the driver has only one hand to interact with the car. Therefore, the participants were asked to think about a steering gesture in the same maneuverer while for example holding a mug.

The steering gesture for the different maneuvers was used in the context of three different variants to gain insight in every potential possibility. Each steering gesture was filmed and extra notes were annotated per participant. If participants mentioned anything during the study that was related to the project context, these annotations were noted down. In total, the study took approximately thirty minutes per participant. The different steering gestures were filmed with a camera that was attached at the car above the participants.

7.3.4.2 Data analysis

The data elicited in this study was used for determining steering gestures zones for a steering wheel related to the project. Based on the annotations and the general impression of the experience the users showed towards the topic, conclusions were made. These conclusions deal with participants' general experience and difficulties with the context of steering gestures as well as automation.

7.3.5 Results

During the study participants showed confusion with what was meant with gestures in general. Questions regarding to what a gesture could look like and what possibilities and options were there were frequently mentioned. For example, one repeated question dealt with the uncertainty of the kind of gesture (e.g. touching, pushing, pulling, and pressing). Related to this aspect the question arose if there was any feedback given from the system (e.g. haptic feedback).

Difficulties also were seen with the confusion with the differences between manual and highly automated driving. Participants mentioned that the system should be as simple as possible and therefore no additional gestures would be needed. Besides, there was no difference between the participants' perspective between the zebra crossing and the red traffic light scenario both visualizing the same maneuver. Moreover, the term highly-automated was also too abstract for participants to grasp. Questions on what tasks are taken over by the automation were mentioned. The general concept of highly automation seemed to be unclear.

Another important aspect that was mentioned by the participants was related to the pace of the gestures. Participants mentioned that the pace could determine the speed of the movement. Equal to the gesture pace, the maneuver would be executed.

7.3.6 Conclusion

Based on this study, key questions were developed. For example, related to the steering gesture pace aspect the key question was established if the speed of the gesture has an influence on speed of the maneuver. Moreover, questions related to feedback from a system/steering modality were added.

This key question should function as a guideline and extra kind of support in the prototyping phase during the future workshops. Furthermore, these questions also give the third phase of the workshops a possible direction for the concepts. Based on this study these questions seem to be essential when trying to evolve a concept about steering gestures and understanding the context in general. Due to the participants being unfamiliar with the topic and important functions the system should fulfill (e.g. system feedback, important maneuvers), the key questions are essential to create a concept. On the one hand, the possibility still exists that these questions could prime the participants but on the other hand these questions could also provide a focus to the participants and ensure that the concepts are based on their level of experience. The key questions might also inform the participants of possible options and functions as needed feedback from the system to be even more creative and think about options they maybe would not have thought of beforehand.

Not only were key questions developed based on the results, but also other important aspect could be concluded that are essential for further development of the method. Due to participants demanding a simple system, one scenario would be sufficient for visualizing one maneuver. Furthermore, the scenarios used in the workshops later on should clearly indicate how an automation would interact and which tasks are required from the driver. The task distributions (see section: shared dynamic control) should be made explicitly clear to show that participants are only required to indicate their intention for a maneuver (via a steering gesture) and the associated tasks are taken over by the system.

7.4 *Pilot future workshops*

7.4.1 Design

In this study, an explorative design research was applied. Based on the participatory method of future workshops a workshop was constructed that fit the context as well as fulfilled the criteria. The workshop consisted of three phases ‘introductory phase’, ‘visioning/fantasy’, and ‘implementation phase’.

7.4.2 Participants

Six participants took part in the pilot workshop. The five male and one female participants were technically affine and had prior knowledge regarding highly automated driving due to working in this area.

7.4.3 Materials

A variety of materials was applied in the future workshop. The workshop took place in a large space to assure that for every phase of the workshop enough space would be provided and the room did not need to be switched. The room was equipped with one large table for the first two phases. The participants sat around the table so that everybody could see every participant as well as the moderator and the presentation on a screen/ notice board. The area was also equipped with two extra tables and notice boards for the third phase of the workshop. These areas were separated from each other to prevent groups copying from each other. Snacks and drinks were also provided to the participants due to the length of the workshops.

For each phase, a variety of materials was applied. During the brainstorming phase red and green cards were used for the participants to write their ideas down. During the prototyping phase participants were equipped with post its and other coloured paper. A selection of pencils was used to visualize the concepts.

To guide the workshop a short presentation was prepared containing an overview on the procedure of the workshop and an additional mood board. This mood board visualized future steering concepts as well as steering concepts used in other transportation areas (e.g. cockpit). Moreover, an actual simulation of a flying car in a simulator was used to give the participants an impression on how the required situation could feel like.

7.4.4 Procedure

7.4.4.1 Data collection

The participants were invited to take part in the workshop. In total, the workshop took about three hours. At the beginning of the workshop the participants were informed about general aspects of the workshop (e.g. duration). In addition, the main intention of the workshop was communicated to the participants. The participants were asked to give feedback whenever something was unclear or they had any suggestions for further improvement of the procedure.

The workshop began with a test ride in the simulator for each participant. The participants sat down in a static simulator and were introduced to a simulation that started with driving a car in a city and having the ability to fly over the city. The whole introduction phase took 30 to 45 minutes. Afterwards the brainstorming phase was introduced stating the main intention of the whole workshop to establish a concept for steering a flying car. The guidelines of the brainstorming phase were given to the participants and approximately 15 minutes were allowed to them to note down their wishes as well as possible challenges connected to a future system.

One researcher guided the discussion of the brainstorming phase. Two other researchers noted down feedback and other annotations. Each participant presented their cards and was asked to further elaborate on the annotations. The discussion took approximately 30 to 45 minutes. Next the participants were given a 15-minute break. Due to limited time, the scenario building was skipped and the participants were directly introduced to the following phase.

The main goal of creating a paper-prototype for a future steering concept of a flying car was introduced to the participants. The intention of designing a paper-prototype based on their ideas and the available material was passed to the participants. Before the groups were divided into two subgroups the mood-board was shortly introduced. The participants were told to use the board as inspiration for their concept.

Then the participants had 45 minutes time to create their concept and employ their ideas in a paper prototype. The researchers were available during that time for further questions and observed the process of the groups. Afterwards each group presented their own concept. The presentations were captured on camera for later interpretation. During the last 15 minutes, participants had the opportunity to comment on their experience of the workshop and any ideas for further improvement.

7.4.4.2 Data analysis

The focus of this workshop was mainly on the evaluation of the method and did not deal with the content and data elicited in the workshops themselves. Therefore, a meeting of the three researchers was held to discuss the annotations noted down during the workshop. In addition to the discussion, the evaluation of the participants and their aspects for improvement were also taken into account. Based on these aspects, adaptions were considered that could further improve the method.

7.4.5 Results

Depending on the phase, a variety of evaluation points can be considered. There were also general aspects that were mentioned. A general guideline for the researchers is needed to follow the same structure and process of the workshop. This guideline can then support the researchers on how to deal with discussions and coping with questions from the participants in general. Besides, the distribution of the roles of each researcher needs to be further determined to know who is taking over which part of the workshop and present a united picture to the participants. Another general aspect is related to the duration. Due to limited time, the scenario building was excluded. But during some phases extra time would provide security if something does not work as planned.

During the first phase (trigger part) the participants had difficulties imagining the sketched situation of a steering concept for a flying car. Questions were related to what tasks does the car take over (e.g. level of automation). The simulation gave an impression of what such a situation could feel like but suffered to provide a clear picture on the functionality in detail.

During the brainstorming phase participants wrote all their wishes/challenges on one card. This made it difficult for others to read the cards as well as a clustering of the cards on the notice board was no longer possible. Furthermore, the question arose if the brainstorming needed to be shortened due to the limited time and what such a shortening could look like. During the discussion, it was noted that sometimes wishes and challenges can relate to the same aspect. The next difficulty arose during the discussion of the cards on how to present the cards. One participant mentioned that a positive beginning is always more suitable (e.g. starting with wishes). Followed by the collection of all cards and arguments the further precedence was unclear (e.g. ranking, clustering, categorization). Other issues were related to the situation between the participants. During the collection of the cards discussions developed between the participants. Sometimes the discussions were fruitful but other times the discussion drifted to unrelated topics. The question is when and how to stop these discussions without disregarding the ideas of users. The scenario building was excluded due to limited time. But it seemed that this phase was still essential to stay connected to the user group perspective.

During the last phase participants had issues to think of a concept and develop a vision without having any reference points. In order to support the participants directly during the workshop, key reference points were developed by the researcher as assisting guidance. Another point that seemed to be difficult is the question if a paper prototype provides the most suitable option for visualizing a concept. One participant mentioned a more theatre oriented method could be more suitable.

7.4.6 Conclusion

As mentioned in the section before, a guideline including rules can be established. This would not only support the researchers but also structure the workshop in more detail to prevent difficulties such as participants writing different ideas on one card. By instructing participants beforehand that one card should be used for one statement the cards are later on more easily readable and furthermore can be clustered. This guideline could also include a moderation structure. This structure helps to divide the roles between the researchers to assure that one researcher is responsible for a specific phase and the other researcher assists by taking notes and keeping the time.

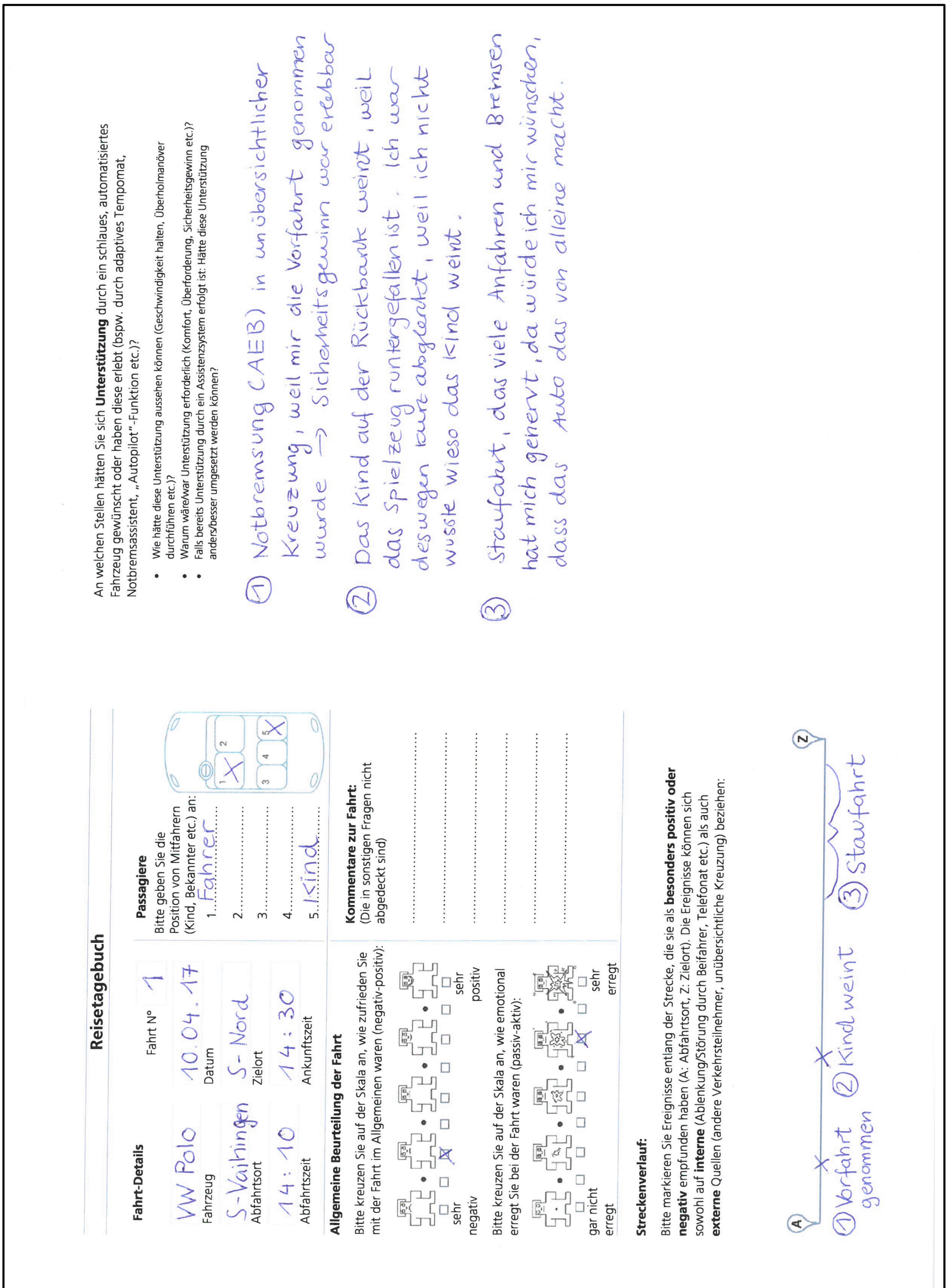
It might be that groups need more time for specific tasks (e.g. longer discussions) or important questions need to be answered before continuing the workshop, therefore an extra time buffer should be implemented that insures that enough time is accessible for each phase and nothing needs to be shortened. If the duration of the workshop is expanded, an extra break should be included. To still limit the duration and keep the workshop as short as possible, phases could be shortened (e.g. limited number of cards per participant during the brainstorming phase). But it seems to be more logical to decide about the duration and limitation of a phase in the situation directly depending on its current usefulness. Some discussions between participants might lead to fruitful ideas and inspire others therefore a situation dependent decision seems to be more logical.

The focus of this workshop did not deal directly with the project (e.g. h-mode) but used a steering concept which is situated far more in the future. This topic gave a perfect context to test a method that needs to be suitable for technology directed towards innovative future scenarios. Due to the focus on approving a concept of a method and evaluating this concept, content data related to the project was not intended. However, the issue still exists that the trigger phase needs to be adapted based on the h-mode project context. However, essential evaluations can still be transferred to an h-mode trigger phase. For example, the need of participants to understand how the tasks are divided between the automation and the driver and what information of the driver is needed by the system (similar to feedback of steering wheel zone study). These aspects are also relevant to the context of the project and should be transferred and adapted in the trigger phase.

Due to time issues the scenario part was skipped. In this context, this seemed to work fine. However, participants could lose connection of the different phases during the workshop if confronted with a scenario they cannot relate to (during the prototyping phase). The scenario phase provides a suitable transition between the brainstorming and the prototyping. If (due to time issues) this phase cannot be included, a predetermined scenario from the diary studies can be applied. But then participants might lose connection to the previous phase if the direction is changed and focus is laid on a different aspect due to a completely different scenario. If possible, a short scenario building should be executed during the workshop.

In the last phase reference points were established during the workshop due to participant having issues to relate important aspects that were needed to their concepts. These references points seemed to support participants and provided guidance. But using such reference points that are developed by a researcher can prime participants and result in a concept that reflects the ideas of the researcher. Therefore, other studies are needed to relate reference/key points directly to the user and let them define important questions.

8 Appendix B: Example 'Diary study'



Reisetagebuch

Fahrt-Details

Fahrt N° 1

VW Polo
Fahrzeug

10.04.17
Datum

S-Vaihingen
Abfahrtsort

S-Nord
Zielort

14:10
Abfahrtszeit

14:30
Ankunftszeit

Passagiere

Bitte geben Sie die Position von Mitfahrern (Kind, Bekannter etc.) an:

1. Fahrer
2. ....
3. ....
4. ....
5. Kind

1 2 3 4 5

Allgemeine Beurteilung der Fahrt

Bitte kreuzen Sie auf der Skala an, wie zufrieden Sie mit der Fahrt im Allgemeinen waren (negativ-positiv):

sehr negativ — sehr positiv

Bitte kreuzen Sie auf der Skala an, wie emotional erregt Sie bei der Fahrt waren (passiv-aktiv):

gar nicht erregt — sehr erregt

Kommentare zur Fahrt:
(Die in sonstigen Fragen nicht abgedeckt sind)

Streckenverlauf:

Bitte markieren Sie Ereignisse entlang der Strecke, die sie als **besonders positiv oder negativ** empfunden haben (A: Abfahrtsort, Z: Zielort). Die Ereignisse können sich sowohl auf **interne** (Ablenkung/Störung durch Beifahrer, Telefonat etc.) als auch **externe** Quellen (andere Verkehrsteilnehmer, unübersichtliche Kreuzung) beziehen:

A — Z

1 Vorfahrt genommen
2 Kind weint
3 Staufahrt

An welchen Stellen hätten Sie sich **Unterstützung** durch ein schlaues, automatisiertes Fahrzeug gewünscht oder haben diese erlebt (bspw. durch adaptives Tempomat, Notbremsassistent, „Autopilot"-Funktion etc.)?

- Wie hätte diese Unterstützung aussehen können (Geschwindigkeit halten, Überholmanöver durchführen etc.)?
- Warum wäre/war Unterstützung erforderlich (Komfort, Überforderung, Sicherheitsgewinn etc.)?
- Falls bereits Unterstützung durch ein Assistenzsystem erfolgt ist: Hätte diese Unterstützung anders/besser umgesetzt werden können?

1 Notbremsung (AEB) in unübersichtlicher Kreuzung, weil mir die Vorfahrt genommen wurde → Sicherheitsgewinn war erlebbar

2 Das Kind auf der Rückbank weint, weil das Spielzeug runtergefallen ist. Ich war deswegen kurz abgelenkt, weil ich nicht wusste wieso das Kind weint.

3 Staufahrt, das viele Anfahren und Bremsen hat mich genervt, da würde ich mir wünschen, dass das Auto das von alleine macht.

9 Appendix C: Instruction/manual diary study

Durch intelligente Fahrzeuge, die Teile der Fahraufgabe selbst übernehmen können, kann der Komfort- und die Sicherheit des Autofahrers gesteigert werden. Im Falle von Menschen mit schweren körperlichen Einschränkungen könnte die Teilnahme am Straßenverkehr dadurch sogar erst ermöglicht werden. In dieser Studie möchten wir herausfinden, wie eine systematische Unterstützung des Fahrers unter der Verwendung von Lenkgesten stattfinden könnte. Hierfür wird zunächst das Projekt und die Grundlagen beschrieben, im Rahmen derer diese Studie stattfindet. Außerdem wird erklärt, was mit Gestensteuerung gemeint ist.

Wie kann man sich die Zusammenarbeit von Fahrer und Fahrzeug vorstellen? Ein möglicher Anhaltspunkt ist die systematische Unterstützung auf Grundlage der Horse-Metapher (H-Metapher), welche im Folgenden näher erläutert wird. In der H-Metapher wird die Interaktion zwischen einem Reiter/Kutscher und einem Pferd systematisch auf die Interaktion zwischen einem Menschen und einem intelligenten Fahrzeug übertragen. Die Interaktion zwischen Reiter/Kutscher und Pferd basiert auf verschiedenen Kommunikationskanälen: Sprechen und Laute, Berührungen und Sehen. Nun stellen Sie sich vor, Sie fahren eine Kutsche. Die Kontrolle in dieser Interaktion zwischen Mensch und Pferd liegt bei Ihnen, dem Menschen. Sie können aber teilweise oder ganz die Kontrolle über die Bewegungsführung an das Pferd abgeben, indem Sie die Zügel lockern oder anziehen. Auf dieser H-Metapher basiert der so genannte H-Mode. In ihrem Fahrzeug könnten Sie also mehr oder weniger Kontrolle abgeben und über verschiedene Kommunikationskanäle mit ihrem Fahrzeug kommunizieren.
Im Rahmen dieser Studie sollen Sie natürlich keine Kutsche lenken, sondern ein Fahrzeug fahren. Die H-Metapher soll Ihnen dazu dienen, sich besser vorzustellen, dass Sie in unterschiedlichen Fahrsituationen mit einem intelligenten Fahrzeug zusammenarbeiten könnten (ähnlich der Zusammenarbeit zwischen Mensch und Pferd).

Ganz konkret möchten wir in diesem Projekt das Autofahren mit Gesten ermöglichen. Das bedeutet, dass Sie an ihrem Lenkrad eine Geste machen und das Auto anschließend ein Manöver ausführt. Abbiegen oder Überholen sind Beispiele für solche Fahrmanöver. Sie können sich vorstellen, dass Sie Ihrem Fahrzeug (zum Beispiel durch ein Streichen von der Mitte des Lenkrades nach rechts, oder ein Antippen des Blinkers) signalisieren, dass Sie abbiegen möchten. Das Fahrzeug übernimmt dann den Vorgang für Sie.

Unser Ziel ist es, möglichst intuitive Gesten zu erkunden und umzusetzen. Dabei ist vorstellbar, dass Sie ihre Gesten an einem klassischen Lenkrad ausführen, aber auch Joysticks, Touchpads oder ähnliche Eingabegeräte sind denkbar.

Kurzer Erinnerungstext

Wie Sie bereits wissen, geht es in diesem Projekt darum, eine Gestensteuerung zu entwickeln, um das Fahren mit Manövern zu ermöglichen. Beispielsweise streichen Sie auf ihrem Lenkrad von rechts nach links und das Auto übernimmt den Abbiegevorgang für Sie. Bezüglich der Eingabegeräte die zur Erkennung von Gesten verwendet werden können, sind Ihrer Phantasie zunächst keine Grenzen gesetzt (es müssen also nicht Lenkräder und Pedale verwendet werden, auch Joysticks, Touchpads, Spracherkennung oder Ähnliches ist denkbar).

10 Appendix D: Informed consent

Datenschutzerklärung

Lenkgestenstudie Juni 2017

Human Factors Engineering, Fraunhofer IAO/Universität Stuttgart IAT

Name des Probanden: ……………………….……………………………………………..

Wohnort des Probanden (Postleitzahl / Ort): ………………….……………………….

Datum, Ort: ……………………...…………………………………………………………

1. Einwilligung zur Teilnahme an der Studie und zur Auswertung und Weitergabe anonymisierter Versuchsdaten (*)

Ich bin mit einer Teilnahme an der Versuchsreihe einverstanden. Die Teilnahme erfolgt freiwillig. Die Versuche können jederzeit abgebrochen werden. Die Versuchsdaten können zur Versuchsauswertung, für Ergebnispräsentationen gegenüber dem Auftraggeber und für wissenschaftliche Veröffentlichungen verwendet werden. Die Versuchsdaten können in anonymisierter Form dem Auftraggeber zur Verfügung gestellt werden.

________________ ____

Datum und Unterschrift des Testteilnehmers/der Testteilnehmerin

2. Einwilligung zur Erstellung von Videoaufzeichnungen (*)

Ich bin damit einverstanden, dass Videoaufzeichnungen, die während der Versuchsreihe erstellt wurden als Bewegt- oder Standbilder von mir in wissenschaftlichen Medien veröffentlicht werden.

________________ ____

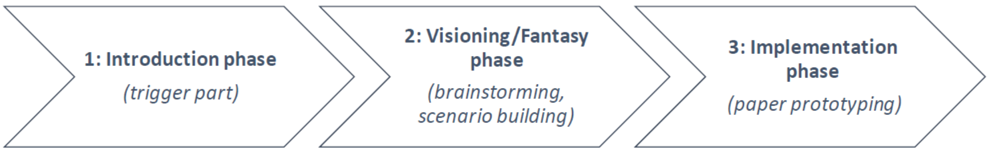
Datum Unterschrift des Testteilnehmers/der Testteilnehmerin

11 Appendix E: Key questions

Leitfragen:

- Wie würdest du dein Kommando abbrechen?
- Spielt es eine Rolle wie lange oder kurz eine Bewegung durchgeführt wird?
- Gibt es Kombinationen von Gesten und weiteren Elementen?
- Wie vermeidet man das eine Geste versehentlich durchgeführt wird?
- Wie kann das Fahrzeug bestätigen, dass es mein Kommando aufgenommen hat?
- Wie kann das Fahrzeug vermitteln welche Manöver es für mich ausführen kann in bestimmten Situationen?
- Wie kann das Fahrzeug bestätigen, dass es mein Kommando ausgeführt hat?
- Welche Informationen möchte ich vom Auto erhalten?
- Welche Informationen braucht das Auto von mir?
- Wie könnte diese Interaktion im Auto für mich sichtbar sein?
- Wie kann ich die Kontrolle ans Auto übergeben/zurückerlangen?
- Wie könnte man eine Intention für verschiedene Manöver dem Auto verdeutlichen? (abbiegen, Spurwechsel, Geschwindigkeit reduzieren/erhöhen, Spur halten, anfahren/anhalten)

12 Appendix F: Workshop manual



Introduction phase:

1. Part 1 (introduction part)
   1.1. Welcome participants
   1.2. Provide participants with information on procedure of workshop (Briefing)
   1.3. Hand out informed consent and let participants sign
2. Part 2 (trigger part)
   2.1. Start with presenting video/commercial

2.2. What does highly automated mean (maneuver) -> specifically illustrate how a situation could look like compared to manual driving, main goal (more comfort, still are able to take over control, dynamic distribution of control)
2.3. After why important, introduce h-mode (text as base for explanation)
2.4. Assure that everything is understood (are there any questions or difficulties?)
3. Part 3 (critique part)
3.1. Introduce method (time, goal, general guidelines)
3.2. Provide participants with cards
3.3. Let them think about ideas and write them down
3.3.1.
3.4. Everyone presents their cards (begin with wishes)
3.5. Depending on time do a ranking with the whole group (what wishes/problems are most important)
3.5.1. How to do this ranking? Everyone can announce top three of each category

Visioning/Fantasy phase:

1. Introduce participants to method
1.1. General guidelines (subgroups, time)
1.2. Question: In which situation would you like to receive additional help as explained in the first phase of the workshop?
1.3. Present example based on previous studies (diary)
1.3.1. where, when, what
1.3.2. Show example video
1.3.3. Can they relate to this scenario? / What do they think about the scenario?
2. Task (if time and example scenarios are difficult to relate to)
2.1. Divide participants into subgroups of 2-3 people
2.2. Assist groups if they need help or support
3. Short presentation
3.1. Every subgroup presents their scenarios

Implementation phase

1. Introduction to method (time, guidelines, material)

   1.1. Group areas with mood board, visualization (present those)
   1.2. Visualizations: ideas to guide them in specific direction (cluster in maneuvers) how do these maneuvers look like?
2. Task and ‘prototyping’
   2.1. Divide group into two subgroups ca. 3 persons per group
   2.2. One researcher per group to guide them and assist if support is needed
   2.3. Keep the group focused on topic steering gestures and assist them with the limitations as well as possibilities of the technology
3. Presentation
   3.1. Presentations are filmed
   3.2. Let each group present their concept
   3.3. After each presentation interview groups based on previous developed question (based on steering gesture study)
4. Ending
   4.1. Debriefing?
   4.2. Thank you and questions

Introduction phase (1.1)	**Introduction part:**	**Notes:**
Overview:	Introduction to overall method and workshop	
Duration:	10-15 minutes	
Technique:	Presentation, Q&A	
Number of researcher:	1	
Purpose:	Inform participants on procedure of workshops and present guideline (informed consent)	
Outcomes:	Sign informed consent, answer possible questions, provide comfortable atmosphere for	

	participants	
Needed material:	Informed consent, power point	
Introduction phase (1.2)	**Trigger part:**	**Notes:**
Overview:	Introduce participants to topic (h-mode as well as automated driving)	
Duration:	15-20 minutes	
Technique:	Presentation (commercial videos for automated driving)	
Number of researcher:	1	
Purpose:	give participants an overview on technical state of the art to provide a direction for workshop, increase participant awareness of what is possible to achieve with technology	
Outcomes:	Participant have a clearer picture on what the goal of this workshop is	
Needed material:	Video, power point	

Visioning/Fantasy phase (2.1)	**Critique part:**	**Notes:**
Overview:	Structured brainstorming that focuses on problems/issues related to question at hand (including integration of diary) as well as wishes towards new system	
Duration:	30-45 minutes	
Technique:	Brainstorming; focus group	
Number of researcher:	1-2	

Purpose:	Establish overview of current issues and difficulties; written down on cards (green, red) -> points are then discussed (and a ranking of problems is going to be established together with participants)	
Outcomes:	Ranking of most important statements	
Needed material:	Whiteboard	
Steps:	1. Give explanation on method 2. **Provide one example for participants** 3. Each participant gets green (wishes) and red (problems) cards **(around ten per person)** 4. Participants are given time to note down their ideas and thoughts (directed to question at hand) on cards: 15-20 min 5. Then every participant present their cards (beginning with positive cards), (Do others have similar ideas?) and are then collected on white board (grouped after similarity) 6. **The session is finished with a discussion to rank/categorize the statements with the whole group**	

Visioning/Fantasy	**Scenario building part:**	**Notes:**

phase (2.2)		
Overview:	encourage participants to think about several example scenarios, cards can function as a base to establish use cases	
Duration:	Max. 30 minutes	
Technique:	Scenario building	
Number of researcher:	2-3	
Purpose:	Retrieving suggestions for future use; helps participants envision future use (example scenarios)	
Outcomes:	Overview on different scenarios with specific information on situation	
Needed material:	Examples (based on use cases and diaries) notice board + paper cards (different colours)	
Steps:	7. Introduce method 8. Present examples (based on developed diary material) 9. Discuss scenarios 10. Six cards labelled 'who', 'when', 'where', 'what', 'how', 'notes' (for any annotations and ideas during process) 11. Write ideas down on cards and let them pin these cards under category 12. Subgroups present their scenarios	3 -> cards serve as a base/backbone

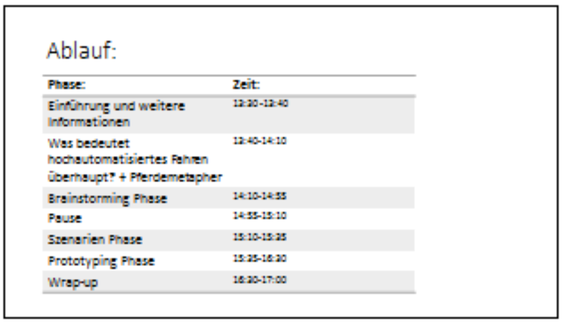
Implementation	Paper prototyping	Notes:

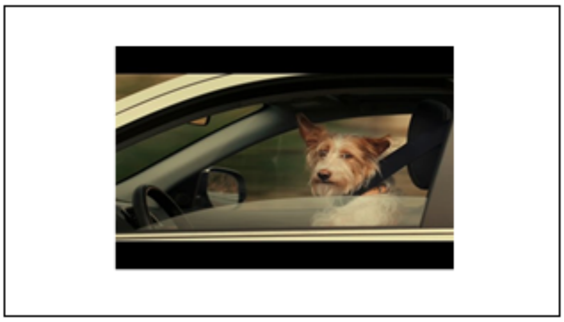
phase (3)		
Overview:	encourage "hands-on experience," and thus support user involvement	
Duration:	60-75 minutes	
Technique:	Adapted paper prototyping, design thinking	
Number of researcher:	2-3	
Purpose:	Give participants chance to interact with 'system' and enable participants to be creative	
Outcomes:	Videos of participants experience and try their preferred options (presentation)	
Needed material:	Visualization of car interior, visualization of current device possibilities (joystick, steering wheel), videos presenting other methods (design thinking, pantomime), mood board (visualizations of future steering concepts), reference points	
Steps:	13. Introduction to procedure 14. Divide group into subgroups 15. Explain situation to participants (scenario as discussed in previous phase) and introduce given material (videos, mood board) 16. Participant can test out options for themselves (researcher functions as a coach: answers questions and reminds goal) 17. Presentation/final discussion of	

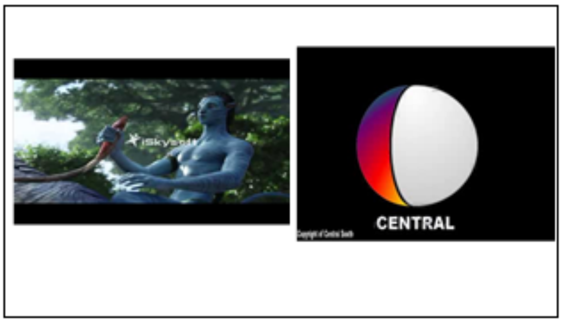
	preferences and any ideas that came up during process (supported by pre-determined questions)	

13 Appendix G: Moodboard

14 Appendix H: Presentation 'Future Workshop'







Wie könnte eine Automatisierung in so einem Fall aussehen?

Beispiel Szenario: 'T-Kreuzung'

Beispiel Szenario: 'Überholvorgang Landstraße'

Beispiel Szenario: 'Zebrastreifen'

Beispiel Szenario: 'Staufahrt Stadt'

Szenarien

Brainstormingphase

- Grüne Karten -> Wünsche und Anforderungen
- Rote Karten -> Herausforderungen und Schwierigkieten
- Pro Karte einen Punkt aufschreiben
- Zeit: 15 Minuten zum Ideen sammeln
- Nach 15 Minuten Präsentation von Karten (individuell)

Pause

10 Minuten

Szenario: Szenariensammlung

- *Einteilung in 2 Gruppen:*
  - *Diskussion und Sammlung von Fällen, in denen Automatisierung hilfreich wäre*

Prototypingphase

- Phase 1:
  - Einteilung in zwei Gruppen
  - Ausarbeitung eines möglichen Konzeptes
- Phase 2:
  - Präsentation des Konzeptes

Leitfragen:

- Wie würdest du dein Kommando abbrechen?
- Spielt es eine Rolle wie lange oder kurz eine Bewegung durchgeführt wird?
- Gibt es Kombinationen von Gesten und weiteren Elementen?
- Wie vermeidet man das eine Geste versehentlich durchgeführt wird?
- Wie kann das Fahrzeug bestätigen, dass es mein Kommando aufgenommen hat?
- Wie kann das Fahrzeug vermitteln welche Manöver es für mich ausführen kann in bestimmten Situationen?
- Wie kann das Fahrzeug bestätigen, dass es mein Kommando ausgeführt hat?
- Welche Informationen möchte ich vom Auto erhalten?
- Welche Informationen braucht das Auto von mir?
- Wie könnte diese Interaktion im Auto für mich sichtbar sein?
- Wie kann ich die Kontrolle ans Auto übergeben/zurückerlangen?
- Wie könnte man eine Intention für verschiedene Manöver dem Auto verdeutlichen? (abbiegen, Spurwechsel, Geschwindigkeit reduzieren/erhöhen, Spur halten, anfahren/anhalten)

15 Appendix I: Steering gesture catalogue

Fraunhofer

IAO

Overview study for intuitive steering gestures:
The study took place at a driving simulator at Fraunhofer IAO. Ten participants took part in the study. Five female and five male participants took part in the study. All participants were right handed.

First the participants were introduced to the study and a general overview was given to them on the procedure. Then they were asked to sit down in the car. In Front of the car a canvas was placed which was used to show videos of the different maneuvers. Per maneuver one video was selected that visualized the scenario from the driver perspective. The videos lasted approximately 15-30 seconds. In total there were six different videos (stopping, starting, changing lanes, right/left turn, zebra crossing).

As the participants sat down the context of a steering gesture was explained (static steering wheel that only recognizes touch). Then the first scenario video was shown to them. At the critical point (e.g. shortly before the traffic lights turned green) the video was stopped. The participants were asked to imagine how they would try to initiate the specific maneuver with a steering gesture. First they were asked to think of the context of manually driving. The second variant was in the context of highly automated driving. In this context the participants were also asked to think on how to signalize to the automation what option they want to choose. The third variant dealt with the context of driving with a limited amount of hands. In some situations there could be the case that the driver has only one hand to interact with the car. Therefore, the participants were asked to think about a steering gesture in the same maneuverer while for example holding a mug.

The steering gesture for the different maneuvers was used in the context of three different variants to gain insight in every potential possibility. Each steering gesture was filmed and extra notes were annotated per participant. In total the study took approximately thirty minutes per participant. The different steering gestures were filmed with a camera that was attached at the car above the participants.

For the analysis of the data all videos were evaluated on their practicability. For example if the steering gesture was chosen to turn the hand towards the driver and the maneuver was ‚stopping‘ the gesture would be rejected because of ergonomic aspects. This was done with every video of a steering gesture and its context. Furthermore, the data of the maneuver ‘stopping at zebra crossing’ did not vary from the maneuver ‘stopping at traffic light’. Almost every participant indicated to initiate this maneuver with the same steering gestures. Therefore, there is no extra part for this maneuver in the catalogue. The final steering gestures were then visualized and depicted in this catalogue. For each steering gesture visualization can be found showing the movement with orange arrows. Furthermore, a short explanation as well as declaration was added that further exemplifies the gesture (e.g. hand position). Also, to every visualization there is a video showing a participant using the gesture.

Beschreibung Deklaration:

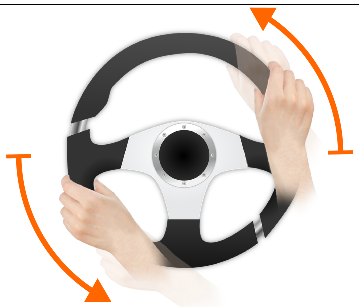
D	Doppelgriff mit beiden Händen	
L	Griff nur mit linker Hand	
R	Griff nur mit rechter Hand	
H	Halb umgriffen (keine Berührung zwischen Daumen und anderen Fingern)	
V	Voll umschlossen (Berührung zwischen Daumen und anderen Fingern	
F	Oberflächliche Berührung mit flacher Hand	
B	Oberflächliche Berührung mit geballter Hand	
n	Fortlaufende Nummerierung	

Manöver ‚rechts abbiegen'

Lenkgeste:	Erklärung	Video Nr.	Deklaration:
	mit flacher linker Hand von links nach rechts über das Lenkrad streichen	**1 (1)**	**LF 1**
	mit beiden Händen fest umschlossen nach rechts streichen	**1 (2)**	**DV 1**
	mit beiden Händen halb umgriffen nach rechts streichen	**1 (7)**	**DH 1**
	mit linker halb umgriffener Hand nach rechts streichen	**1 (6)**	**LH 1**
	mit linker halb umgriffener Hand nach rechts streichen	**1 (3)**	**LH 2**

	mit linker flacher Hand nach rechts streichen	**1 (5)** **1 (10)**	**LF 2**
	mit rechter flacher Hand nach rechts streichen	**1 (4)**	**RF 1**
	mit rechter flacher Hand nach rechts streichen über die Mitte des Lenkrades streichen	**1 (9)**	**RF 2**
	mit rechter flacher Hand Lenkrad auf der rechten Seite antippen	**1 (11)**	**RF 3**

Manöver ‚links abbiegen'

Lenkgeste:	**Erklärung**	**Video Nr.**	**Deklaration:**
	mit flacher linker Hand von rechts nach links über das Lenkrad streichen	**2 (2)**	**LF 3**
	mit halb umgriffener linker Hand von rechts nach links über das Lenkrad streichen	**2 (6)**	**LH 3**
	mit beiden Händen voll (halb) umgriffen nach links streichen	**2 (1)** **2 (5)**	**DV 2**
	mit halb umgriffener linker Hand von rechts nach links über das Lenkrad streichen	**2 (4)**	**LH 4**
	mit flacher linker Hand von rechts nach links über das Lenkrad streichen	**2 (3)** **2 (8)**	**LF 4**

	mit linker flacher Hand Lenkrad auf der linken Seite antippen	**2 (9)** **2 (7)**	**LF 5**

Manöver ‚anhalten'

Lenkgeste:	**Erklärung**	**Video Nr.**	**Deklaration:**
	mit beiden Händen voll umschlossenen nach unten streichen	**3 (2)** **3 (6)**	**DV 3**
	mit halb geballter Faust die Mitte des Lenkrades berühren	**3 (1)**	**RB 1**
	mit beiden Händen voll umschlossenen nach unten streichen	**3 (3)**	**DV 4**

	mit rechter Hand voll umschlossenen nach unten streichen	**3 (4)**	**RV 1**
	mit rechter flacher Hand von oben über die Mitte des Lenkrades nach unten streichen	**3 (5)**	**RF 4**

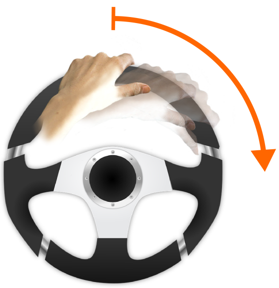
Manöver ‚anfahren'

Lenkgeste:	**Erklärung**	**Video Nr.**	**Deklaration:**
	mit beiden Händen nach oben streichen wobei die Hände von flacher Hand zu voll umschlossen übergehen	**4 (1)**	**DF-V 5**
	mit beiden Händen voll umschlossen nach hinten drehen	**4 (2)**	**DV 6**

	mit beiden Händen voll umschlossen nach oben streichen	**4 (3)**	**DV 7**
	mit linker voll umschlossener Hand nach vorne drehen	**4 (4)**	**LV 2**
	mit flacher rechter Hand von rechts nach links streichen und wieder zurück	**4 (6)**	**RF 5**
	mit beiden Händen voll umschlossen nach oben streichen	**4 (5)**	**DV 8**
	mit beiden Händen voll umschlossen nach oben drehen	**4 (7)**	**DV 9**

	mit Handrücken und flacher Hand von unten über die Mitte des Lenkrades nach oben streichen	**4 (8)**	**RF 6**
	mit flacher rechter Hand die Mitte des Lebkrades berühren	**4 (9)**	**RF 7**

Manöver ‚Spurwechsel'

Lenkgeste:	**Erklärung**	**Video Nr.**	**Deklaration:**
	mit linker halb umgriffener Hand nach rechts streichen	**5 (1)**	**LH 5**
	mit beiden Händen fest umschlossen nach rechts streichen	**5 (2)**	**DV 10**
	mit linker halb umgriffener Hand nach rechts streichen	**5 (3)**	**LH 6**

	mit flacher linker Hand von rechts nach links streichen und wieder zurück	**5 (5)**	**LF 6**
	mit rechter flacher Hand Lenkrad auf der rechten Seite antippen	**5 (4)**	**RF 8**

16 Appendix J: Screening questionnaire for future workshops

„Lenkgesten für das Auto der Zukunft"

Im Rahmen eines Projektes vom Fraunhofer IAO werden wir am 07.06.17 und am 08.06.17 Workshops mit Probanden veranstalten, um gemeinsam mögliche Szenarien und Anforderungen zum Thema „Lenkgesten" zu diskutieren. Hierbei wollen wir mit Ihnen zusammen Ideen und Visionen zur Gestaltung von Lenkgesten im hochautomatisiertem Fahren entwickeln.

Bitte beantworten Sie uns bei Interesse vorab einige Fragen, sodass wir Ihre Eignung für die Teilnahme an diesem Projekt sicherstellen können. Selbstverständlich werden Ihre Daten vertraulich behandelt und nur zweckgebunden für das o.g. Projekt ausgewertet.

1. **Bitte geben Sie uns einige Auskünfte zu Ihrer Person.**

Vorname:	
Nachname:	
Geschlecht:	
Alter (Jahre):	
Beruf:	

2. **Wie viel Kilometer fahren Sie pro Jahr?**
   - ☐ unter 5000
   - ☐ 5000-15000
   - ☐ über 15000

3. **Bitte kreuzen Sie die Aussagen an die auf Sie zutreffen.**
   - ☐ Ich liebe es, neue elektronische Geräte zu besitzen.
   - ☐ Elektronische Geräte erleichtern mir den Alltag.
   - ☐ Ich kenne die meisten Funktionen der elektronischen Geräte, die ich besitze.

4. **Haben Sie bereits Erfahrung mit modernen Assistenzsystemen wie ACC/Distronic, Spurhalteasistent?**
   - ☐ ja
   - ☐ nein

5. Für die geplanten Workshops stehen zwei **Termine** zur Verfügung. Bitte geben Sie Ihre Verfügbarkeit an (Mehrfachnennung möglich).

   Ich kann teilnehmen am ….

   - ☐ **Mittwoch, 07.06.17 von 13-16:30 Uhr**
   - ☐ **Donnerstag, 08.06.17 von 13-16:30 Uhr**

Vielen Dank für Ihre Angaben. Wir werden diese im Laufe der nächsten Tage sichten und Ihnen bis spätestens zum **05.06.2017** Bescheid geben, ob wir Ihnen eine verbindliche Zusage für Ihre Teilnahme an diesem Projekt geben können.

Fraunhofer IAO

UNIVERSITY OF TWENTE.