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Conceptual design and evaluation of a human machine interface for highly automated truck driving

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Abstract— **Vehicle automation is linked to various benefits such as an increase in fuel and transport efficiency, as well as an increase in driving comfort. Automation also comes with a variety of downsides e.g. loss of situation awareness, loss of skills as well as inappropriate trust levels regarding system functionality. Drawbacks differ between automation levels. As highly-automated driving (level 3) requires the driver to take over the driving task in critical situations within a limited period of time, the need for an appropriate human-machine interface (HMI) arises. To foster adequate and efficient human-machine interaction, this contribution presents a user-centered, iterative approach for HMI design for highly-automated truck driving.**

An expert workshop was conducted to develop first ideas and HMI sketches. Workshop results were combined with scientific findings regarding HMI design for highly-automated car driving. Based on those findings, a paper prototype was created and evaluated with experts, using an approach of mixed qualitative methods (heuristic evaluation, thinking aloud). The outcome was implemented to the HMI concept. In a third step, the HMI was conceptualized as video prototype enabling a more detailed evaluation. Again, experts were asked to assess the HMI using qualitative (thinking aloud) and quantitative methods (questionnaires).

The result represents a video prototype showing a HMI strategy for highly-automated driving, aiming at fostering a successful human-machine interaction. Relevant issues such as drivers' informational needs, situation awareness and trust were explicitly considered during HMI design. Next steps comprise HMI implementation and user evaluation in a driving simulator to let users experience the HMI in a semi-real driving context.

I. Introduction

Automation of vehicles is currently one of the most widely-discussed topics in research and industry, claiming to positively enhance the overall transportation system in terms of improved safety, reduced road congestion as well as economic competitiveness and driver comfort [1].

Nevertheless, vehicle automation comes with various downsides, mainly affecting the driver. Loss of skills, loss of situation awareness, inappropriate trust ratings regarding the systems' capabilities are just a few factors negatively influencing the promised benefits [2]. Depending on the level of automation, supposed drawbacks differ. In highly-automated driving (level 3), the driver does not have to monitor the system permanently [3]. Instead, the vehicle will provide the driver with a takeover request in the event of system failure, indicating that the driver has to take over the driving task again. Hence, the driver is able to engage in other tasks than driving during phases of highly-automated driving.

Research investigated the ideal takeover time. Results indicate that various aspects such as driver state (e.g. workload level, fatigue, motivation, age, individual abilities) as well as engagement in and characteristic of non-driving related tasks influence the takeover time. According to [4] it is more difficult to interrupt intrinsically motivated non-driving related tasks than extrinsicically motivated tasks. The perceived task difficulty also influences task involvement and induced workload leading to longer takeover reactions. The detected takeover time differs between 1.1s and 40s, depending on the experimental setting [5–8].

Most research has been conducted in the area of highly-automated driving in cars. So far, the profession of truck driving cannot be easily compared with regular car driving [9]. Driving hours are longer and overall pressure on drivers is higher due to a general shortage of drivers and time constraints as a result of just-in-time delivery. Conducted research might be taken as a first insight but cannot be transferred one by one onto the domain of truck driving.

II. Research Aim

The aim of this research is the iterative design and evaluation of a suitable HMI for highly-automated truck driving considering prevailing findings from literature. The first research question derived is:

Q1: What does an ideal HMI strategy for highly-automated driving look like?

During the development process possible downsides, originating from highly-automated driving such as reduced situation awareness shall be explicitly taken into account. The second research question addresses the concept's usability:

Q2: How do experts evaluate the conceptual HMI regarding usability in terms of efficiency, effectiveness and usefulness?

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III. OVERALL METHOD

As the overall method for HMI design and evaluation, the user-centered design process (fig.1) was applied [10]. This approach consists of four phases including the understanding and specification of context of use (1), the specification of user requirements (2), the creation and development of design solutions (3) as well as product evaluation (4). The final solution is ultimately compared with the underlying user context as well as the derived user requirements [fig.1]. All steps follow an iterative approach, meaning that every phase is passed through several times until the ideal solution, fitting user needs and requirements, is found. The four phases can be addressed individually with different qualitative and quantitative methodological approaches.

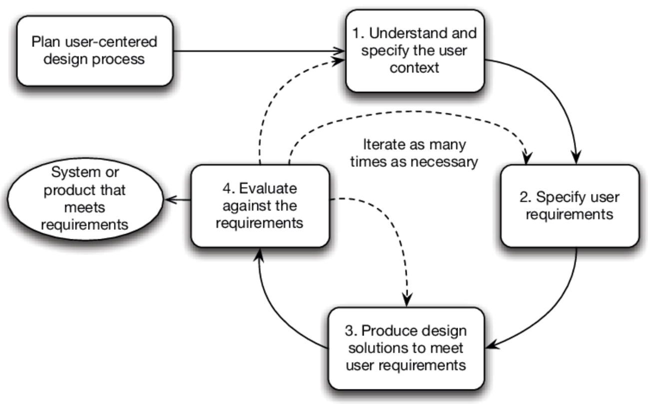

Figure 1. Figure 1: User-centered design process based on DIN EN ISO 9241:210 [10]

Specific context information (1) has been collected using online questionnaires and semi-structured interviews with truck drivers and fleet managers. Subject areas were truck drivers and fleet managers' general attitudes towards highly-automated driving as well as the identification of concerns and perceived benefits. [11]

Specific user requirements (2) were explored with expert surveys, user focus groups and a driving simulator study [9]. The subject matter was related to truck drivers' informational needs during highly-automated driving. Detailed information about the chosen methodology and results can be found in [9]. In summary, results show that truck drivers require information regarding navigation, current system status, present traffic surrounding, feedback on system actions, as well as information on current and planned system maneuvers. Furthermore, informational needs differed between traffic situations, with complex situations showing a greater informational demand. Within takeover scenarios, information regarding the prevailing traffic surroundings as well as recommendation for action showed greater importance. Scenarios that could be handled by the system require information about the present system status and the planned maneuvers.

Within this contribution, the development of suitable design solutions (3) is presented.

IV. EXPERT WORKSHOP: WORLD CAFÉ

To develop first design concepts, an expert workshop in the form of a so called world café [12] was conducted.

A. Method

In total, nine HMI experts from industry and university took part. Experts were provided with the results found in the previous studies, regarding specific user needs and requirements [9, 11].

Experts were given a summary of current technologies, suitable for displaying relevant content in a truck (e.g. head-up displays, augmented and virtual reality tools, flexible organic light-emitting diode (OLED) displays). Furthermore, information on possible non-driving related tasks was presented. Additionally, different control elements were gathered and depicted. To foster creativity, personas were created. Experts were advised to include all given information into their concepts. The moderator asked the experts to imagine creating HMI concepts for a serial vehicle truck, taking into account the prevailing requirements given by the truck cabin dimensions.

B. Results

Figure 2 shows the final elaborated HMI concept realized as low fidelity prototype (sketch).

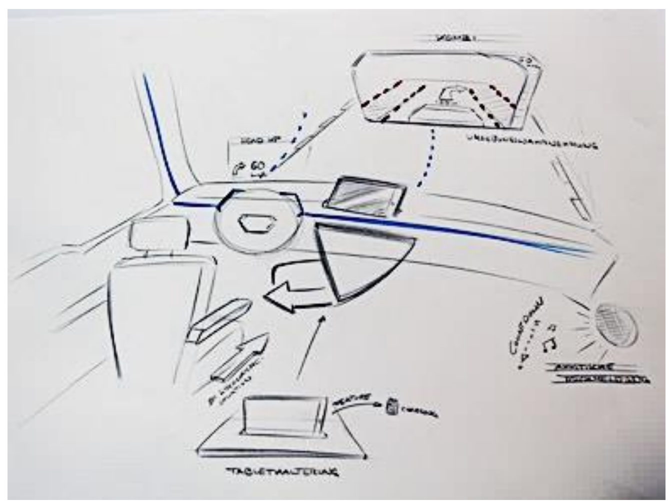

Figure 2. Figure 2: Final elaborated HMI sketch for highly-automated truck driving

The final concept incorporates different elements. Experts suggest a movable chair able to slide backwards and forwards, aiming at indicating the current system status. Furthermore, an extendable table as well as a display medium for secondary task involvement should be provided for the driver.

The HMI comprises five elements:

1. LED bar
2. Head up display
3. Instrument cluster
4. Augmented reality in front screen
5. Combined central information (CID) and entertainment display

For displaying the prevailing system status, the LED bar is used. The head-up display contains relevant navigational information such as current driving speed. Augmented reality elements are used to highlight current and planned system maneuvers as well as surrounding vehicles. Maneuvers are also depicted in the instrument cluster and the entertainment display. Furthermore, truck drivers should be acoustically supported during takeover requests using speech and earcons. Haptic feedback is used as a final warning signal indicating an urgent takeover.

C. *Discussion*

The HMI concept depicts a first idea on how an adequate HMI strategy for highly-automated truck driving could be realized. Current findings from previous studies on driver needs were included in the concept by providing the information to the experts.

To further increase the level of detail, the sketch is compared and enhanced with current findings from literature regarding HMI design for highly-automated driving. Literature suggests that, for enhancing situation awareness and system understanding, information regarding the current system status, currently-planned maneuvers and the prevailing surrounding is important [13, 14]. In terms of trust, information on why automation failed or why automation executes various actions is necessary [15–18]. These findings are in accordance with results from [9] in which drivers' explicitly asked for feedback on system actions as well as current surrounding.

V. Paper Prototype

Based on the sketch, paper prototypes were elaborated. In comparison to sketches, paper prototypes offer a more detailed statement due to a higher resolution and level of detail. The paper prototypes presented represent holistic, horizontal prototypes, showing a complete interface on an upper functional level. Deeper functionality (vertical prototype) has not been implemented within this stage.

The results from literature were incorporated in the subsequent paper prototypes. As results and advice from literature varies, three alternative prototypes were realized. All concepts differed in terms of amount of takeover phases (3 vs. 2), amount of displays, interior adjustments, information localization as well as representation of the remaining time until takeover.

Figure 3 shows paper prototype 1 including the four stages system availability (1), system activation (2), preparation for takeover (3) and final takeover (4). Layout of the instrument cluster and CID were depicted on a separate screen.

To further reduce concept alternatives and obtain a more detailed insight regarding localization of information, all prototypes were evaluated within an expert study.

A. *Method*

The expert study involved five experts. Experts' area of expertise covered HMI development as well as development of driver assistance systems. The number of experts is derived from Nielsen [19, 20] who states that five test persons are enough to find most of the prevailing usability issues within a usability test.

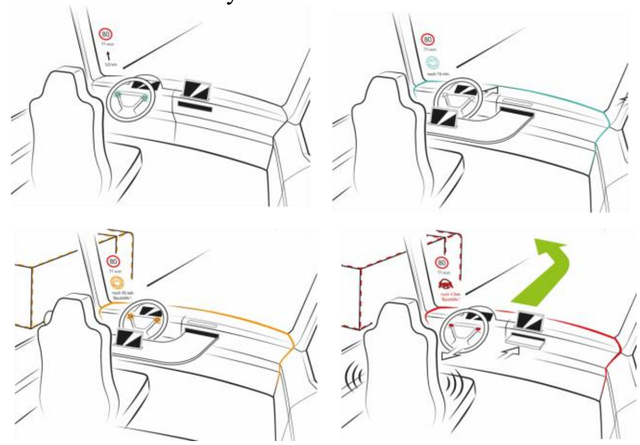

Figure 3. Figure 3: Paper prototype 1 showing the four possible HMI phases:
top left (1 – system availability shown by green steering wheel buttons), top right (2 – system activation), bottom left (3 – preparation phase for takeover), bottom right (4 – final takeover)

The expert study was substantively divided into three parts. First, experts had the opportunity to explore the concept individually, applying the thinking-aloud method. All relevant aspects named were recorded using audio. After exploration, the moderator explained the idea of the concept and the elements implemented. In the subsequent part, experts were requested to evaluate the concept applying the approach of a heuristic evaluation. Therefore, experts evaluated all aspects of the HMI concept using Nielsen's [21] general principles for interaction design. A heuristic evaluation hardly requires formal training, is quickly applicable and allows usability problems to be identified in an early development stage [22].

This three-step procedure was repeated for all concept alternatives in a randomized order to prevent sequential effects. After exploring the different concepts, experts filled out a final questionnaire, rating different aspects of the HMI concept such as localization and presentational format of information.

B. *Results*

Results show that experts favor the concept in which the automation availability is presented via combination display, illuminated steering wheel buttons and an acoustical cue. Navigational and environmental information should be presented in the combination as well as in the CID. In the event of a takeover scenario, drivers' attention should be evoked by using speech instruction and the LED bar indicating a takeover via color change. In addition, seat oscillation can be used to further enhance drivers' takeover performance. To prevent mode confusion, experts agreed, that manual driving should be the final fallback level.

Experts' opinion differed regarding displaying the remaining time until the driver has to take over the driving task. In addition, there was no consensus on the number of takeover stages (4 including orange phase vs. 3 without orange phase).

C. Discussion

Both sketches and paper prototypes were designed to address research question Q1, giving an insight into what an ideal HMI strategy for highly-automated driving could look like. Experts' evaluation gave improvement indications regarding HMI design. The findings obtained were considered within the following iteration phase and included in the design of a video prototype.

VI. Video Prototype

Based on the findings resulting from the paper prototype evaluation, a video prototype was built.

A video prototype represents a film sequence showing the usage of an interactive system within a planned context [23]. Thus, it is possible to provide test subjects with a temporal component, enabling a deeper understanding of the concept within the specified context. In regards to the development of an HMI strategy for highly-automated driving, test subjects get a more detailed insight into the design of the takeover strategy and the interaction of the different HMI elements involved.

In total four different prototype alternatives were built, varying in terms of displaying the remaining time until a takeover occurs and the presentation of a preparation phase for takeover (e.g. green-orange-red vs. green - red).

TABLE I. Video Prototype alternatives; Orange phase starts 60 sec before takeover; red phase starts 10 sec before takeover

Prototype alternatives	Countdown (yes/no)	Preparation phase
Prototype 1	Yes	green – orange – red
Prototype 2	Yes	green – red
Prototype 3	No	green – orange – red
Prototype 4	No	green – red

A. Research question

The evaluation of the video prototype addressed research question two (Q2) concentrating on the concepts' usability in terms of efficiency, effectiveness and usefulness. In addition to that, experts were asked to assess the concept regarding mode confusion, trust, correctly-guided attention, mental workload and the evocation of correct takeover actions. Additionally the question whether or not the remaining time until highly-automated driving ends as well as the remaining time until a takeover occurs should be presented, is determined.

B. Method

Five experts, different from the paper prototype evaluation, from the field of HMI and function development took part in the expert study. In a first step, experts were asked to watch the first two videos applying the method of thinking aloud. Experts were allowed to watch each video twice and to stop the video occasionally if needed. The same procedure was reiterated with prototype 3 and 4 (tab. 1). After having watched all video prototype alternatives, experts assessed the HMI concept's general usability using the standardized ISONORM 9241 questionnaire [24] and the system usability scale (SUS – 5-point Likert scale) [25].

The ISONORM 9241 questionnaire (7-point Likert scale; 0 ≙ ---; 6 ≙ +++) is grouped into seven subscales following dialog principles, namely:

1. Task suitability
2. Self-descriptiveness
3. Controllability
4. Conformance with user expectations
5. Fault tolerance
6. Customizability
7. Learnability

Additionally, experts rated the concept according to six selected desirable aspects for HMI evaluation developed by Beukel [26]. Items are answered on a 7-point Likert scale (0 ≙ fully disagree; 6 ≙ fully agree). The criteria ask whether the concept is able to:

1. Provide appropriate trust
2. Avoid mode confusion
3. Avoid confusion about the driver's role
4. Avoid erroneous counter reactions
5. Influence mental workload to be at a moderate level
6. Direct attention to vital information

C. Results

Results of the ISONORM 9241 questionnaire (fig. 4) reveal high scores on task suitability (mean: 4.8), self-descriptiveness (mean: 4.8), conformance with user expectations (mean: 5.2) and learnability (mean: 4.7). Controllability (mean 4.1) and fault tolerance (4.1) score less highly. The subscale customizability shows the lowest value with a mean of 3.2.

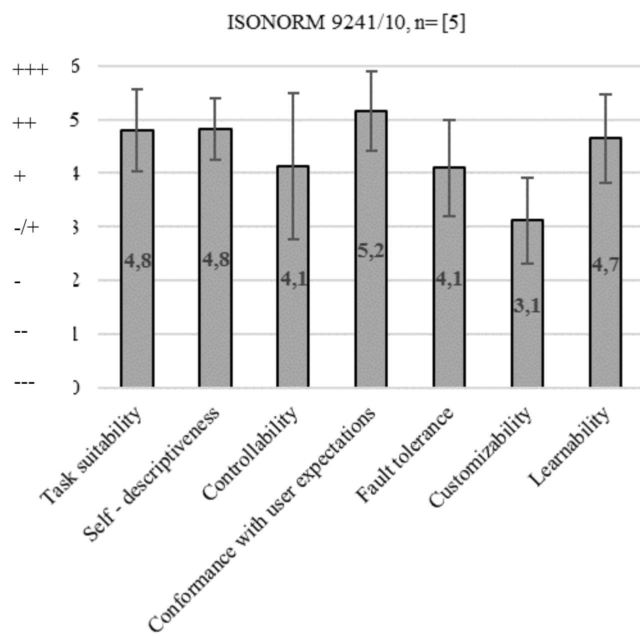

Figure 4. Figure 4: ISONORM9241/10 results (mean values and standard deviation bar)

Analysis of Beukel's desirable aspects for HMI evaluation [26] (fig. 5) indicates that the HMI concept is able to avoid mode confusion (mean: 5.6), influence workload to be at a moderate level (mean 5.3) and also avoid confusion about the driver's role (mean 5.0). Ratings on correctly-guided driver attention (mean 4.6), creation of appropriate trust (mean 4.4) and correct take over reactions (mean 4.2) score less highly.

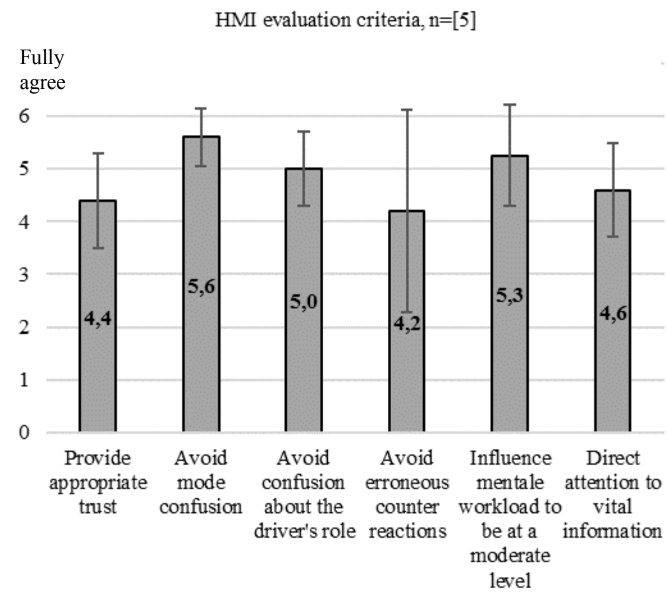

Figure 5. Figure 5: Results of Beukel's evaluation criteria (mean values)

Analysis of the SUS (ranging from 0-100 points) reveals an overall score of 80.5, indicating an acceptable system (fig. 6).

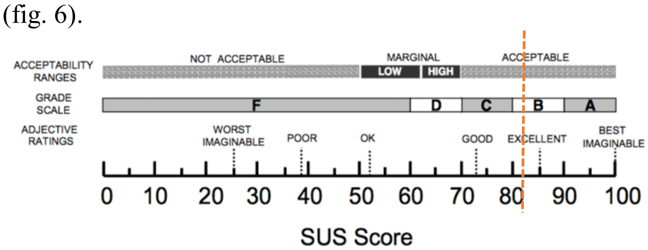

Figure 6. Figure 6: Final SUS score (80.5) [n=5] indicated by dashed line

Experts did not reach a consensus decision on whether the remaining time until takeover should be displayed. There was a joint view in terms of preparation stages. Experts stated that the orange preparation phase should be presented whenever a situation is foreseeable for the system. The chosen color concept and the overall designed takeover strategy (multimodal, phased) were mentioned positively.

D. Discussion

The results obtained from the ISONORM 9241 questionnaire show overall good performance of the HMI concept. Yet, there is room for improvement. Especially in terms of controllability, the HMI concept needs to be optimized further.

Results also show poorer scores for fault tolerance. These results might be traced back to the fact that experts related fault tolerance not only to the HMI concept. Instead the highly-automated system functionality was included into evaluation. A highly automated driving system is, by definition, linked with sensor failure or critical situations that cannot be handled by the system leading to takeovers. Within this stage of automation (level 3), it is not possible to provide an error free system.

Customizability scores lowest of all criteria. As the HMI concept is designed to support the driver in safety critical takeover situations and enable the driver to maintain situation awareness, users should not be able to individualize the HMI.

Analysis of Beukel's [26] desirable HMI evaluation aspects indicates lower scores for the establishment of appropriate trust, evocation of correct takeover reactions as well as the direct guidance of user attention to the correct place of information. The results could be explained by the fact that these criteria need to be explicitly experienced in a driving simulator with a more realistic environment. Within a simulator study, it is possible to obtain data that is more valid in terms of takeover time and quality as well as trust ratings. To evaluate whether drivers' attention is correctly guided through the HMI concept, eye tracking could be used.

SUS scores indicate a good overall usability. This result is in line with the results obtained from the ISONORM questionnaire. Nevertheless, one must take into consideration that the SUS is a "quick and dirty" method for evaluating usability. Hence, the rating should be taken as rough direction.

There was no consensus opinion on the depiction of the remaining time until takeover (10 second countdown). Experts stated that drivers might show slower take over reactions when 10 seconds of takeover time are assured. On the other hand, drivers might be put under stress when a takeover request is prompted by the system without a remaining amount of time being displayed. Additionally there was no consensus whether the remaining time until highly-automated driving ends should be depicted. Experts noted that displaying the time enables the driver to efficiently plan their secondary task engagement. On the other hand, the depiction of the overall remaining time until highly-automated driving ends might confuse the driver as short-term takeover request could occur at any time.

VII. CONCLUSION

This contribution addressed the conceptual design and evaluation of a HMI for highly automated truck driving. For HMI design an iterative approach, based on the DIN ISO 9241/210 was chosen. HMI development started with an expert workshop, following the design and evaluation of a paper and video prototype, respectively. Results show good usability overall. Next steps include the optimization of the HMI concept due to experts' feedback as well as the implementation in a driving simulator. Following the HMI concept is tested in a driving simulator study with truck drivers evaluating takeover time as well as overall usability.

ACKNOWLEDGMENT

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development, study design and data analysis. Christoph Lehmer contributed to literature review, data collection, HMI development and data analysis. Britta Michel and Markus Lienkamp revised the manuscript critically for important intellectual content. The research presented was conducted in cooperation with MAN Truck & Bus AG.

References

[1] H. Winner, S. Hakuli, F. Lotz, and C. Singer, Eds., *Handbuch Fahrerassistenzsysteme*. Wiesbaden: Springer Fachmedien Wiesbaden, 2015.

[2] I. Othersen, *Vom Fahrer zum Denker und Teilzeitlenker: Einflussfaktoren und Gestaltungsmerkmale nutzerorientierter Interaktionskonzepte für die Überwachungsaufgabe des Fahrers im teilautomatisierten Modus*. Wiesbaden: Springer Fachmedien Wiesbaden, 2016.

[3] T. M. Gasser, *Rechtsfolgen zunehmender Fahrzeugautomatisierung: Gemeinsamer Schlussbericht der Projektgruppe; Bericht zum Forschungsprojekt F 1100.5409013.01*. Bremerhaven: Wirtschaftsverl. NW, Verl. für neue Wiss, 2012.

[4] I. Petermann-Stock, L. Hackenberg, T. Muhr, and C. Mergl, Eds., *Wie lange braucht der Fahrer?: Eine Analyse zu Übernahmezeiten aus verschiedenen Nebentätigkeiten während einer hochautomatisierten Staufahrt*, 2013.

[5] C. Gold, I. Berisha, and K. Bengler, "Utilization of Drivetime - Performing Non-Driving Related Tasks While Driving Highly Automated," *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, vol. 59, no. 1, pp. 1666–1670, 2015.

[6] N. Merat, A. H. Jamson, F. C.H. Lai, M. Daly, and O. M.J. Carsten, "Transition to manual: Driver behaviour when resuming control from a highly automated vehicle," *Transportation Research Part F: Traffic Psychology and Behaviour*, vol. 27, pp. 274–282, 2014.

[7] M. Kühn, M. Vollrath, and T. Vogelpohl, *Übergabe von hochautomatisiertem Fahren zu manueller Steuerung: Teil 1. Review der Literatur und Studie zu Übernahmezeiten*. Berlin: Unfallforschung der Versicherer, GDV, 2016.

[8] F. Wulf, M. Rimini-Doring, M. Arnon, and F. Gauterin, "Recommendations Supporting Situation Awareness in Partially Automated Driver Assistance Systems," *IEEE Trans. Intell. Transport. Syst.*, vol. 16, no. 4, pp. 2290–2296, 2015.

[9] N. Richardson, B. Michel, A. Zimmermann, and F. Diermeyer, "Erfassung und Bewertung des Informationsbedarfs von Lkw-Fahrern während hochautomatisierter Fahrt," in *9. VDI Tagung: Der Fahrer im 21. Jahrhundert. Der Mensch im Fokus technischer Innovationen*, VDI Wissensforum GmbH, Ed., Düsseldorf: VDI Verlag GmbH, 2017.

[10] *Ergonomie der Mensch-System-Interaktion – Teil 210: Prozess zur Gestaltung gebrauchstauglicher interaktiver Systeme*, 9241-210:2010, 2011.

[11] N. Richardson, F. Doubek, K. Kuhn, and A. Stumpf, "Assessing Truck Drivers' and Fleet Managers' Opinions Towards Highly Automated Driving," in *Advances in Intelligent Systems and Computing, Advances in Human Aspects of Transportation*, N. A. Stanton, S. Landry, G. Di Bucchianico, and A. Vallicelli, Eds., Cham: Springer International Publishing, 2017, pp. 473–484.

[12] J. Brown, D. Isaacs, and W. Cafe Community, *The World Café: Shaping Our Futures Through Conversations That Matter*. San Francisco: Berrett-Koehler Publishers Inc, 2005.

[13] A. Kleen *et al.,* "Automatische Fahrfunktion und Mobile Devices: HMI- Konzept "Active Frame": Darstellung von system- und umweltbezogenen Informationen auf Tablet PCs während der automatischen Fahrt," in Wolfsburg, 2014.

[14] M. Beggiato *et al.,* "What would drivers like to know during automated driving? Information needs at different levels of automation.," pp. 1–6, 2015.

[15] J. Beller, M. Heesen, and M. Vollrath, "Improving the Driver–Automation Interaction," *Human factors*, vol. 55, no. 6, pp. 1130–1141, 2013.

[16] S. Stockert, N. T. Richardson, and M. Lienkamp, "Driving in an Increasingly Automated World – Approaches to Improve the Driver-automation Interaction," *Procedia Manufacturing*, vol. 3, pp. 2889–2896, 2015.

[17] T. Helldin, G. Falkman, M. Riveiro, and S. Davidsson, "Presenting system uncertainty in automotive UIs for supporting trust calibration in autonomous driving," in *Proceedings of the 5th International Conference on Automotive User Interfaces and Interactive Vehicular Applications - AutomotiveUI '13*, Eindhoven, Netherlands, 2013, pp. 210–217.

[18] K. A. Hoff and M. Bashir, "Trust in automation: integrating empirical evidence on factors that influence trust," (eng), *Human factors*, vol. 57, no. 3, pp. 407–434, 2015.

[19] J. Nielsen, *How Many Test Users in a Usability Study?* [Online] Available: https://www.nngroup.com/articles/how-many-test-users/. Accessed on: Nov. 02 2017.

[20] J. Nielsen and T. K. Landauer, "A mathematical model of the finding of usability problems," in *Proceedings of the SIGCHI conference on Human factors in computing systems - CHI '93*, Amsterdam, The Netherlands, 1993, pp. 206–213.

[21] J. Nielsen, "Enhancing the explanatory power of usability heuristics," in *Proceedings of the SIGCHI conference on Human factors in computing systems celebrating interdependence - CHI '94*, Boston, Massachusetts, United States, 1994, pp. 152–158.

[22] A. Sears, "Heuristic Walkthroughs: Finding the Problems Without the Noise," *International Journal of Human-Computer Interaction*, vol. 9, no. 3, pp. 213–234, 1997.

[23] A. Butz and A. Krüger, *Mensch-Maschine-Interaktion*. München: Oldenbourg Wissenschaftsverlag GmbH, 2014.

[24] J. Prümper and M. Anft, *ISONORM 9241/110 (Langfassung): Beurteilung von Software auf Grundlage der Internationalen Ergonomie-Norm DIN EN ISO 9241-110.* [Online] Available: people.f3.htw-berlin.de/Professoren/Pruemper/…/ISONORM%209241-110-L.pdf. Accessed on: Nov. 02 2017.

[25] J. Brooke, *SUS: a "quick and dirty" usability scale*. London: Taylor and Francis, 1986.

[26] van den Beukel, A. P., & van der Voort, M. C., "Design considerations on user-interaction for semi-automated driving," in *Proceedings of the FISITA 2014 World Automotive Congress*, Maastricht, 2015, pp. 1–8.