DEVELOPMENT OF A PERFORMANCE-BASED PROCEDURE FOR SAE LEVEL 2 DRIVER ENGAGEMENT ASSESSMENTS

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ABSTRACT

Adapting the performance and design of Advanced Driver Assistance Systems (ADAS) and Automated Driving Systems (ADS) to human capabilities and safety needs is an important requirement for a safe market introduction of new technologies in this field. A specific challenge for SAE Level 2 systems is the engagement of the driver in the driving task. A high level of driver engagement is necessary to ensure that drivers are able to fulfill their role and responsibility to monitor the system performance and to intervene in system limit situations. However, effectiveness of current driver monitoring technologies to ensure driver engagement are limited with broadly diversified performance parameters. Therefore, the aim of the current research was to develop and validate a standardized procedure for performance-based assessments of driver engagement of Level 2 systems with a direct link to safety by focusing on controllability in accident-prone system limit situations. In total, 39 drivers without prior experience in continuously assisting systems participated in the evaluation study on a test track. To assess the validity of the procedure and the standardized test scenario, half of the participants experienced a Level 2 system (Tesla Autopilot) while the other half drove the same vehicle (Tesla Model 3) conventionally (fully manual). The participants task was to constantly follow a lead vehicle, driven by a second experimenter, on a round course for approx. 30 minutes. At the end of the test drive an accident-prone system limit situation without a prior system-initiated warning was triggered: The lead vehicle performed a cut-out maneuver revealing a stationary crash target in front of the participant. Without driver intervention, the Level 2 system was not able to avoid a collision. Therefore, the participant was required to react by braking and/or steering. Results indicate that the test scenario is controllable by conventional drivers. No driver of this group caused a collision or had a Time-To-Collision minimum below 1 second. However, drivers of the Level 2 system specifically used in the study had difficulties in controlling the system limit situation and intervening adequately to avoid a collision with the stationary target. 15% of these drivers collided with the target and approx. 50% had a Time-To-Collision minimum below 1 second. Furthermore, the median Time-To-Collision minimum of the Level 2 drivers was approx. 1.5 seconds lower compared to conventional drivers. Concluding, it can be stated that the test scenario is in general controllable by conventional drivers but, due to a lack of driver engagement of the Level 2 system tested in the study, participants of this group had problems in intervening adequately to the system limit. In summary, the developed procedure is a pragmatic, reliable and valid way to assess driver engagement independently and in a design-neutral way by focusing on safety critical interaction behavior in system limit situations.

INTRODUCTION

Safety of SAE Level 2 Systems is strongly linked to a high level of driver engagement. This is especially important as drivers are required to intervene immediately to system limits, even without any prior warning or information given by the system [1]. Hence, driver engagement includes a continuous monitoring of the system performance as well as of the driving environment by the driver, being able to identify situations requiring an immediate intervention. Taking this into account, driver engagement is at least a visual as well as a cognitive task [2]. However, effectiveness of current driver monitoring technologies to ensure driver engagement is rather limited. These technologies are able to asses motoric (hands on the steering wheel) as well as visual (eyes on the road) driver behavior only. There is currently no technical solution available in series production vehicles to assess if a driver has understood the system performance as well as the driving situation by means of driver monitoring technologies. Furthermore, although all of the systems available today are labeled as Level 2 systems, systems of different manufacturers show a different operational behavior and system performance. Hence, these differences in system design can influence the quality and safety of human-machine-interaction (HMI) and driver engagement in several ways making it an important topic for consumer protection organizations and type approval authorities to focus on [3]. Therefore, the aim of the current research is to develop and validate a standardized procedure for performance-based assessments of driver engagement of Level 2 systems with a direct link to safety by focusing on controllability in accident-prone system limit situations.

Safety assessments of series production vehicles in Europe are performed by the European New Car Assessment Program (EuroNCAP). In 2018 and 2020, EuroNCAP already performed safety assessments of Level 2 systems by a separate grading in addition to the regular safety rating [4, 5]. For the first time, the 2020 grading used a balance principle for the final scoring and grading, combining the assessment of vehicle assistance competence on the one hand as well as driver engagement on the other hand. The balance principle was introduced to emphasize the importance of a good driver engagement in relation to an increasing vehicle assistance. Finally, considering also safety backup functions in addition, a 4-point grading system, from 'entry' over 'moderate' to 'good' and 'very good', was created. To assess the driver engagement component of the grading, consumer information, system status, driver monitoring and driving collaboration aspects are analyzed by EuroNCAP experts. The assessment basically is focused on concrete system design aspects, for example display icons and colored indicators for certain system status information. However, the safety impact of these design aspects in relation to real driver behavior was neither parameterized nor analyzed so far. The balance principle here is lacking a real comparison of objective driver behavior to objective system performance. Assessing driver engagement directly by analyzing real driver behavior, could create a more naturalistic and valid assessment approach with a direct link to measurable safety outcomes and can therefore close this gap. However, the feasibility and reliability of direct driver-based assessment procedures in consumer protection is still an open research question.

Controllability and Safety Assessment of Human-Machine-Interaction

Safety assessments of HMI for assisted and automated driving are often performed by human factors experts based on a set of defined design requirements and design checklists (for example see [6]). The requirements or checklist items are usually derived from international standards or guidelines. However, the safety outcome is limited to the individual interpretation of the requirements by the experts. Furthermore, requirements consider only individual aspects of a safe system design (for example certain display icons for system status indications), but usually do not testify about the user-system-interaction as a whole (for example do users understand their role and responsibility in interaction with the system?). This can only be done by analyzing user understanding and behavior in concrete interaction with a holistic system. The Take-over controllability (TOC) rating for Level 3 systems, developed by [7], goes one step further. Video material of control transitions from automated to manual driving is assessed by trained raters in a standardized procedure. The TOC rating is used to analyze concrete and observable driver behavior in a safety relevant scenario, the takeover situation. However, since the TOC rating is limited to control transitions from automated to manual driving only and safety of HMI with regard to driver engagement for assisted driving requires different aspects, at least an adaptation of the procedure and rating categories seems necessary. There is a strong relation between research on controllability and the safety assessment of HMI. However, relevant safety indicators are often operationalized and assessed heterogeneously. [8] and [9] applied subjective ratings as well as objective criteria in different driving simulator studies, to assess controllability of Level 2 systems. On a test track, [10] tested the controllability in accident prone-system limit situations in different experiments. The authors describe, that participants often showed severe problems in controlling the vehicle in front of a target, although having their hands on the steering wheel as well as their eyes on the road. [11] found similar effects. Results suggest the importance for consumer protection and type approval to take a closer look at controllability and safety of HMI and driver engagement. However, appropriate procedures are still missing here.

Research Questions

To address the feasibility, reliability and validity of driver-based assessment procedures for safety assessments of HMI and driver engagement of SAE Level 2 systems, the study focused on three different research questions: 1) Is it possible to measure and assess safety of HMI of SAE Level 2 systems in a standardized procedure with performance-based metrics? 2) Do drivers of a Level 2 System show a different interaction behavior in a safety critical test scenario compared to conventional drivers driving completely in manual control without any continuous system support? 3) Is the defined test scenario in general controllable by conventional drivers driving completely in manual control?

METHODS

Test vehicle

The study was conducted with a Tesla Model 3 (model year 2020), using the Level 2 system Tesla Autopilot (ACC combined with Tesla Auto-Steer) in the Level 2 system condition (software version v10.2, 2021.4.18.2).

While using the system, drivers are required to permanently leave their hands on the steering wheel. Taking hands away from the steering wheel would result in hands-off warnings. ACC speed should be set to 60 kph by the participants. The initial distance to the lead vehicle was put to the closest setting. However, it was up to the participant to change the distance to another setting, but no participant made use of this option. In the control condition, participants where driving the same vehicle conventionally (fully manual) without any continuous system support. They were asked to keep a close distance to the lead vehicle, as they would usually do when driving at a similar speed on a two-lane road.

Test track

The study was conducted on a test track in Bad Sobernheim, Germany. The 1.6 km-long one-way round course with two fully marked lanes (lane width: 3.30 m) provided different radii of left and right curves as well as straight sections of different length to allow participants to experience the system behavior in different driving situations (see Figure 1). Due to safety reasons, apart of a second experimenter driving a vehicle in front of the participant during the whole experiment, there was no surrounding traffic or other road users on the track.

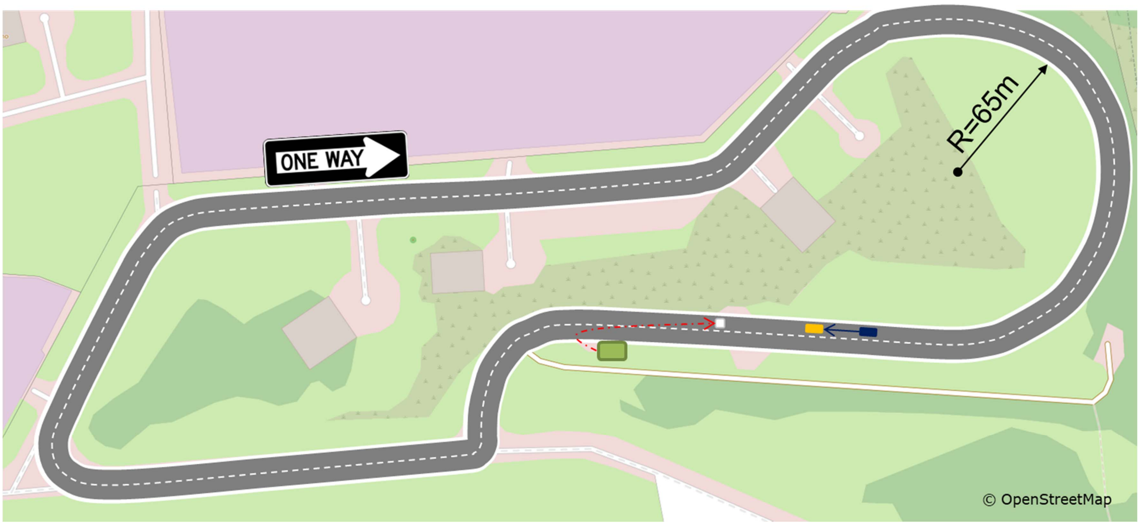

Figure 1. Test track in Bad Sobernheim, Germany.

Test Scenario

To be a suitable test scenario for the safety-related results of adequate driver engagement in Level 2, we consider the situation needs to be a system limit requiring the human driver to intervene. To emphasize the intervention by the driver, the situation should be highly salient and intuitively understood by manual drivers as well as drivers using a Level 2 system. Therefore, a standardized vehicle cut-out scenario was used in the study. A crash target was positioned manually in the center of the driving lane on a straight section of the test track. To reduce the possibility for the participant to anticipate the situation beforehand, the target was hidden in a tent next to the track prior to the scenario. When the lead vehicle, driven by a professional driver, approached the stationary target at a speed of 60 kph, the driver performed an evasive steering maneuver with a full lane change to the left lane. The driver was trained to start the maneuver at a TTC of approximately 1 s (distance to target approx. 15 m) with a maximum lateral acceleration of approximately 7 m/s^2. In case the participant did not react early enough, a Forward Collision Warning (FCW) was issued and an Autonomous Emergency Braking (AEB) maneuver started. However, without driver intervention, a collision with the crash target was caused. The participant could avoid a collision by braking or steering to the left lane. Due to the curvature, the target was visible for the participant for at least 10 seconds prior to the collision.

Study Procedure

Arriving at the test track, participants were welcomed and told a cover story that in the following they would experience a new vehicle and should assess its use and comfort during a test drive. After signing an informed consent form, participants received a safety briefing about safe behavior at the test facility. Afterwards, they were asked to read an excerpt of the user manual. In the Level 2 system condition, a part of the user manual explaining ACC and Auto-Steer was provided to participants while participants in the manual driving condition were provided with an excerpt of general vehicle functions. The user manual of the Level 2 system instructed drivers to always keep their hands on the steering wheel and pay attention, since use of the system can be limited at any time and the driver is still fully responsible for driving safely. In case of a system limit, drivers were told to intervene immediately. After reading the user manual, participants were escorted to the test track and seated in the driver seat. One experimenter took a seat on the passenger seat right next to the participant. The experimenter explained briefly the general vehicle control as well as basic system functionality. The test drive was started, if participants indicated that they felt comfortable with the vehicle control. The experimenter on the passenger seat gave the instructions to drive in the right lane, follow the lead vehicle driving in front and use the Level 2 system as often as possible during the drive. Overtaking was not permitted. The speed of the Level 2 system should be set by the participants to 60 kph and distance to the vehicle ahead was pre-set to the closest possible option. The distance to the lead vehicle could be changed by the participant, but no participant attempted to do so. Manual drivers were asked to follow the lead vehicle as close as they would usually do when driving at a similar speed. Effective driving speed during the experiment was adjusted to the respective track section by the second experimenter (professional driver) driving the vehicle in front. After 14 laps (approximately 30 minutes driving time), a standardized system limit test scenario was initiated by a third experimenter who was waiting out of sight of the participant around the track. The third experimenter placed a crash target in the center of the driving lane (see Figure 2). Beforehand, the target was hidden in a tent right next to the test track, so that the scenario and situation could not be anticipated by the participant. When the second experimenter driving the lead vehicle performed a sudden lane change in front of the target to the left lane, the target came into direct sight. It was now the participant's task to avoid a collision with the stationary target by immediately intervening by braking and/or steering.

Figure 2. Left: Schematic overview of the cut-out maneuver performed by the lead vehicle (green) in front of the stationary crash target (white). Center, Right: The target is hidden in a tent and not visible for participants prior to the test scenario, where it is placed in the center of the driving lane by a third experimenter.

During the whole test drive, participants were observed by the first experimenter on the passenger seat and their interactional behavior was assessed using a standardized, tablet-based assessment and rating tool developed by [12]. Altogether, each test drive lasted about 35 min. Participants received a financial compensation of 30 Euros for their participation in the study.

Test Criteria

The assessment was performed according to recommendations of the RESPONSE III Code of Practice (CoP) [15]. The CoP defines that 85% of a driver population is able to control a defined system limit situation, if all drivers (100%) from a representative sample of n=20 participants are able to control the vehicle in the respective situation. The CoP recommends that the definition of adequate pass-fail criteria should be situation and system specific. Accordingly, for this study, in total three different criteria based on the dependent measures were defined:

- All participants (100%) are able to avoid a collision with the stationary target in the cut-out situation [15].
- The mean TTCmin value of each test vehicle group to the stationary target is >1.0 s ([16], [8]).
- Each participant´s reaction in the cut-out situation is assessed uncritical (< 7) on the standardized scale (see Figure 3) for a general safety rating of driver-vehicle-interaction by the first experimenter [8].

The scenario is failed, if one or more of the three criteria are failed.

Figure 3. General safety rating of driver-vehicle-interaction, standardized on a 11-point scale based on [13] and [14].

Experimental Design

The study was carried out in a between-subjects design with one experimental factor ´Level of Assistance`. Participants were either experiencing a Tesla Autopilot SAE Level 2 system ('Level 2') during the test drive or driving fully manually without any continuous system support ('Conventional Driving'). Participants were assigned randomly to the experimental condition. All participants independent of experimental condition experienced the standardized system limit at the end of the driving trial. There was no variance in order or length of the driving trial.

Participants

In total, *n*=39 drivers (12 females) participated in the study. Participants were recruited by newspaper and social media announcements in the local area of the test track. Mean age of the recruited sample was 41.31 years (*SD*=15.74, *MIN*=19, *MAX*=68). All participants held a valid driver's license, had normal or corrected to normal vision and no previous practical experience with advanced driver assistant systems (e.g. ACC, active lane centering etc.). With regard to age, gender or reported annual driving experience, the two experimental groups did not differ significantly. In total, *n*=20 participants were experiencing the Tesla Autopilot system ('Level 2') while *n*=19 participants were driving fully manually ('Conventional Driving').

RESULTS

In the following, the impact of the experimental factor ´Level of Assistance` on the different objective and subjective dependent measures of the study is described and analyzed. For the cut-out scenario, the mean TTCmin-values of the test vehicle to the stationary target as well as the frequency of collisions with the stationary target are used as dependent objective variables and the general safety rating of driver-vehicle-interaction by the first experimenter as a dependent subjective measure.

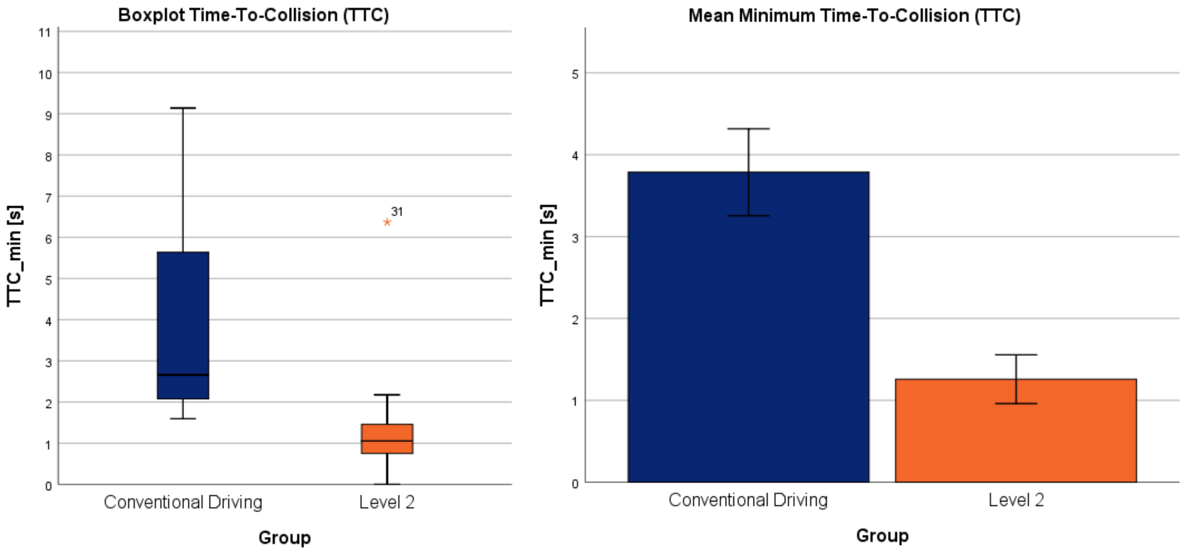

Figure 4. Left: Boxplots for the TTCmin-values by experimental condition (group). Whiskers represent minimum/maximum values within ± 1.5*IQR. 1st Quartile defines, that 25% of the TTCmin-values are lower. 3rd Quartile defines, that 75% of the TTCmin-values are lower. Right: Mean TTCmin-values by experimental condition.

The TTCmin-value distribution as well as the mean TTCmin-values of two different groups for the scenario are shown in Figure 4. The factor ´Level of Assistance` has a significant influence on the reaction of the drivers in front of the target, leading to significantly lower TTCmin-values for drivers driving with the Tesla Autopilot system (*M*=1.26s, *SD*=1.30s) compared to drivers driving fully manually without any continuous system support (*M*=3.79s, *SD*=2.25s, *t*(28.45)=4.15, *p*<.001). The mean TTCmin of manual drivers is more than 2.5s higher compared to the Tesla Autopilot drivers. Although the mean TTCmin-value for both groups is higher than the defined critical value of 1s, results show that 50% of Tesla Autopilot drivers have a TTCmin value <1s compared to 0% of drivers driving fully manually. However, the second controllability criterium is passed for both groups.

Taking the frequency of collisions with the stationary target vehicle into account, on a descriptive basis, there is a tendency towards higher collision rates for drivers driving with the Tesla Autopilot system (*n*=3) compared to drivers driving fully manually (*n*=0), but the difference is statistically not significant ($X^2=3.07$, *df*=1, *p*=.079). However, since it was defined that all participants (100%) should be able to avoid a collision with the stationary target in the cut-out situation, the first controllability criterium was failed for the Tesla Autopilot system.

The driver's response towards the stationary target is further analyzed by means of the standardized safety ratings of the first experimenter. As can be seen in Figure 5, the response is rated dangerous and critical (standardized scale value >7) for 20% of the drivers driving with the Tesla Autopilot system compared to 0% of drivers driving fully manually. Therefore, the third controllability criterium is failed for the Tesla Autopilot system. Furthermore, the response for drivers driving with the Tesla Autopilot system is also rated significantly more critical on average (*M*=4.00, *SD*=3.23) compared to drivers driving fully manually (*M*=0.47, *SD*=0.96, *t*(22.53)=-4.67, *p*<.001).

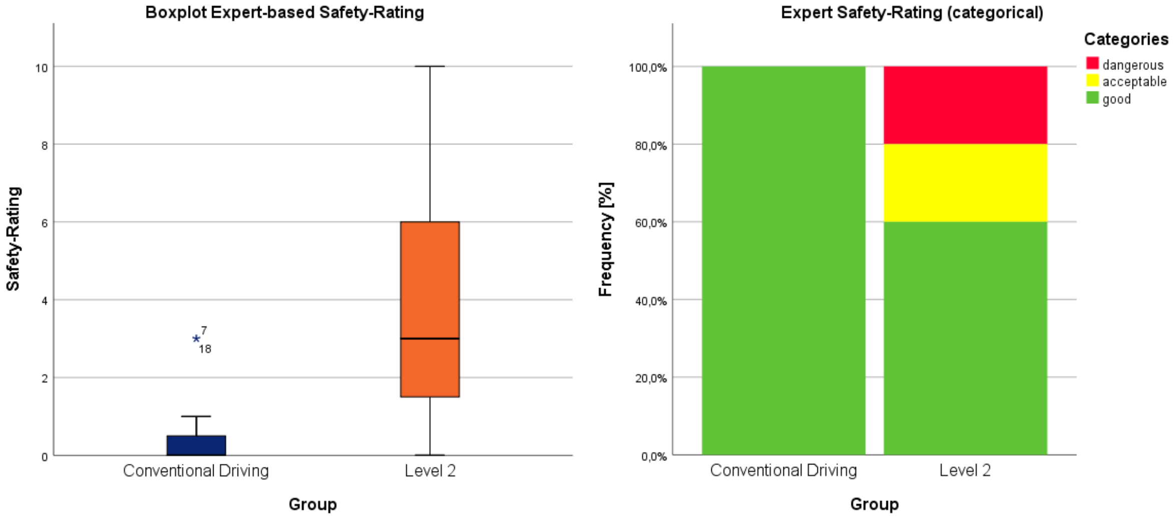

Figure 5. Left: Boxplots for the standardized safety ratings of the first experimenter by experimental condition (group). Right: Frequency of safety ratings per category by experimental condition.

Considering the objective TTCmin-values as an external validity criterium for the measurement of the subjective safety rating by the first experimenter, there is a strong correlation effect of *r*=-.574 (*p*<.01) for the cut-out scenario. The standardized safety ratings can therefore be seen as a valid indicator for HMI safety assessments. Furthermore, considering reliability of the method, there is also a strong inter-rater agreement between the first experimenter performing the rating within the vehicle and a second rater analyzing recorded video data (*ρ*=.706, *p*<.01).

DISCUSSION

The aim of the current research was to address the feasibility, reliability and validity of a driver-based assessment procedure for safety assessments of HMI and driver engagement for SAE Level 2 systems. In total, 39 drivers without prior experience in continuously assisting systems participated in the study on a closed test track. To assess the validity of the procedure and the standardized test scenario, one half of the participants were experiencing a Level 2 system (Tesla Autopilot) while the other half were driving the same vehicle conventionally (fully manual). The participants task was to constantly follow a lead vehicle, driven by a second experimenter, on a round course for approx. 30 minutes. At the end of the test drive an accident-prone system limit situation without a prior system-initiated warning was triggered: The lead vehicle performed a cut-out maneuver revealing a stationary crash target in front of the participant. Without driver intervention, the Level 2 system was not able to avoid a collision neither was the AEB-System given the initial following distance to the vehicle in front and speed. Therefore, the participant was required to react by braking and/or steering. The study aimed at assessing safety of HMI in a standardized procedure with performance-based metrics. The first research questions focused on the possibility to use these metrics to define interaction-related safety outcomes. In accordance to the RESPONSE III CoP three different pass-fail criteria were defined. Results show that all three criteria could be applied for the safety assessment in a practical way. Approx. 15% of the Level 2 drivers were not able to avoid a collision with the stationary target and 20% of these drivers were rated critical or dangerous on the standardized safety rating scale by the first experimenter. Therefore, the first and the third safety criteria was failed by the respective Level 2 system (Tesla Autopilot) used in the study. The second criteria did not focus on individual participants behavior but the mean TTCmin on a group level. As defined by [16], a TTCmin below 1s is related to a safety critical situation. Due to one outlier with a TTCmin of 6.3s in the group of the Level 2 drivers, the mean TTCmin of the group was >1s. However, 50% of drivers in this group still had values below 1s compared to no driver in the group of conventional drivers. It is therefore questionable, if the criterium is useful and valid on a group level by calculating the mean value. The assessment could probably be improved by defining specific quantities or frequencies (e.g. median or 1st quartil >1s).

The second research question focused on the behavior differences of Level 2 drivers and conventional drivers. Results indicate a difference between the two groups. No manual driver caused a collision in the test scenario and the reaction of all manual drivers was rated ‘good’ by the trained rater. Furthermore, the TTCmin of all conventional drivers was above 1 s. Therefore, the procedure seems to be a suitable approach to detect and assess difference in safety relevant driver behavior in the chosen scenario. Since no one of the conventional drivers showed any difficulty in avoiding a collision with the stationary target, the scenario itself seems to be in general controllable. Therefore, the third research question can clearly be answered yes. However, results also indicate that there is a large variance in the behavior of manual drivers in the face of the stationary target. Some drivers changed the lane even before the lead vehicle started the cut-out maneuver. This shows that human drivers are highly capable of anticipating risky situations, even before they actually happen. However, in most cases Level 2 drivers in the study lacked this anticipatory behavior. Most of these drivers waited for the system to solve the situation or warn the driver to intervene. Although all drivers independently of experimental condition had their hands on the steering wheel and their eyes on the road in the test scenario, the reaction of Level 2 drivers was delayed most of the time. Manual drivers often reduced their speed and increased their distance to the lead vehicle when the stationary target became visible for the first time, approximately 5-10 s prior to the calculated target impact. By doing so, these drivers gained time to observe what would happen in the ambivalent situation, long before the actually critical cut-out maneuver would take place. Level 2 drivers in the study usually missed their opportunity to increase distance to the lead vehicle when the target became visible. One reason for this could be that increasing the distance to the lead vehicle while using ACC would either take some time and require several pushes on a button or mean to directly lose system support completely by applying the brakes. Assuming that drivers are motivated to maximize their individual use of the system, this might demotivate them from using the brakes early to increase the distance to the lead vehicle when the situation is not yet a clear system limit.

CONCLUSIONS

Based on the experience of the study, the standardized assessment procedure for safety of human-machine-interaction was perceived pragmatic and feasible for testing purposes of consumer protection and type approval. There was a large difference in safety indicators between conventional driving and the Level 2 system used in the study. This is an indicator, that the test scenario is in general controllable by human drivers and due to specific interaction related problems of Level 2 systems, drivers show difficulties in intervening at the system limit. It became clear, that manual and Level 2 drivers showed different behavior patterns facing the target situation. However, the concrete variance between different Level 2 systems is still unclear. More experience and data are necessary for a comprehensive consideration and further development of the method.

REFERENCES

[1] SAE International Standard J3016. (2021). “Taxonomy and Definitions for Terms Related to On-Road-Motor Vehicle Automated Driving Systems”

[2] Pradhan, A. K., Crossman, J., & Sypniewski, A. (2019, June). Improving driver engagement during L2 automation: a pilot study. In *Driving Assesment Conference* (Vol. 10, No. 2019). University of Iowa.

[3] Carsten, O., & Martens, M. H. (2019). How can humans understand their automated cars? HMI principles, problems and solutions. *Cognition, Technology & Work*, 21(1), 3-20.

[4] EuroNCAP (2018). 2018 Automated Driving Tests: https://www.euroncap.com/en/vehicle-safety/safety-campaigns/2018-automated-driving-tests/

[5] EuroNCAP (2020). 2020 Assisted Driving Tests: https://www.euroncap.com/en/vehicle-safety/safety-campaigns/2020-assisted-driving-tests/

[6] Naujoks, F., Wiedemann, K., Schömig, N., Hergeth, S., & Keinath, A. (2019). Towards guidelines and verification methods for automated vehicle HMIs. *Transportation Research Part F: Traffic Psychology and Behaviour*, 60, 121-136.

[7] Naujoks, F., Wiedemann, K., Schömig, N., Jarosch, O., & Gold, C. (2018). Expert-based controllability assessment of control transitions from automated to manual driving. *MethodsX*, 5, 579-592.

[8] Naujoks, F., Purucker, C., Neukum, A., Wolter, S., & Steiger, R. (2015). Controllability of partially automated driving functions–does it matter whether drivers are allowed to take their hands off the steering wheel?. *Transportation Research Part F: Traffic Psychology and Behaviour*, 35, 185-198.

[9] Naujoks, F., Purucker, C., Wiedemann, K., Neukum, A., Wolter, S., & Steiger, R. (2017). Driving performance at lateral system limits during partially automated driving. *Accident Analysis & Prevention*, 108, 147-162.

[10] Victor, T. W., Tivesten, E., Gustavsson, P., Johansson, J., Sangberg, F., & Ljung Aust, M. (2018). Automation expectation mismatch: Incorrect prediction despite eyes on threat and hands on wheel. *Human Factors*, 60(8), 1095-1116

[11] Pipkorn, L., Victor, T. W., Dozza, M., & Tivesten, E. (2021). Driver conflict response during supervised automation: Do hands on wheel matter?. *Transportation Research Part F: Traffic Psychology and Behaviour*, 76, 14-25.

[12] Schömig, N., Wiedemann, K., Julier, R., Neukum, A., Wiggerich, A., & Hoffmann, H. (2021). Methoden für die Bewertung der Mensch-Maschine-Interaktion beim teilautomatisierten Fahren. Berichte der Bundesanstalt für Straßenwesen, Reihe F: Fahrzeugtechnik (F 141). Bremen: Fachverlag NW in der Carl Ed. Schünemann KG.

[13] Kaussner, Y. (2013). Assessment of driver fitness: An alcohol calibration study in a high-fidelity simulation. Paper presented at the Fit to Drive 7th International Traffic Expert Congress, Berlin, 25.04.-26.04.2013.

[14] Kaussner, Y., Hoffmann, S., Fischer, F. & Kenntner-Mabiala, R. (2013). SPDE_DFA: S.A.F.E: Anleitung zur Durchführung von Fahrverhaltensbeobachtungen mit der Standardized Application for Fitness to Drive Evaluations (S.A.F.E.) am Tablet-PC. Würzburg, 2013.

[15] RESPONSE Consortium (2006). Code of Practice for the Design and Evaluation of ADAS. *RESPONSE 3: A PReVENT Project.*

[16] Hayward, J. C. (1972). Near-miss determination through use of a scale of danger. *Highway Research Record* (384).