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Collecting end-users needs regarding driver state-based automation in the ADAS&ME project

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Abstract

The EU funded project ADAS&ME (Adaptive ADAS to support incapacitated drivers & Mitigate Effectively risks through tailor made HMI under automation) develops adapted Advanced Driver Assistance Systems. A web based survey was designed to collect the opinion of ADAS&ME end-users about automated functions that could support the driver/rider during different driving tasks. In total, 1094 persons answered the survey. The results reveal that most of the participants had heard of automated functions previously, and that about half of them also had experience using such functions. Several participants indicated concerns about data security. Furthermore, the results give an insight into how end-users perceive automation and what they see as advantages and limitations for implementation of automated driving systems corresponding to the ADAS&MEs' goals.

Keywords: automation; survey; end-users; driver-state.

1. Introduction

Traffic safety research assumes that approximately 80% of crashes are due to human error. In reality, the percentage of driver/rider and other traffic participant errors in crash causation is even higher (Singh, 2015). But what we fail to understand is how and why even experienced drivers can cause serious crashes. One explanation is hidden in the physiology of the human brain and the psychology of human behaviour resulting in drivers not being attentive, being fatigued, stressed under pressure of negative emotions, etc. To compensate for human errors and thereby provide a safer and more comfortable experience for the driver; modern technologies are developed. These include cooperative intelligent transportations systems, automated driving systems, automated safety functions, and driver monitoring, which are all believed to be important to assure a safe and pleasurable transport system.

In the EU-funded research project ADAS&ME (Adaptive ADAS to support incapacitated drivers & Mitigate

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Effectively risks through tailor made HMI under automation) a holistic approach is embraced in the development of such technology, with a specific focus on driver/rider state monitoring. ADAS&ME aims at developing adapted Advanced Driver Assistance Systems that incorporate driver/rider state, situational/environmental context, and adaptive interaction to automatically transfer control between vehicle and driver/rider and thus ensure safer and more efficient road usage. The work is based around 7 indicative Use Cases (UC) for cars, trucks, buses and motorcycles. Those cover a substantial proportion of driving on European roads.

At the start of the project the 7 UC were consider as indicative and the first part of the project was addressed to take different stakeholders view into consideration when defining and prioritizing among them. The output with the final selection is the framework for the development and evaluation done in the project. The methodological approach included a collection of a broad set of empirical data using focus groups and workshops, as well as surveys targeting stakeholders and end-users input. Based on the indicative use cases the methodology is used to prioritize and tune the final Use Cases of ADAS&ME. This is also what represent the innovative part of the paper (Figure 1).

This paper addresses the end-user's involvement and presents the results from the questionnaire through which their feedback on the first indicative Use Cases was collected.

2. Method

In ADAS&ME the methodology for Use Case scenario and their prioritization and selection are based on several different methods summarized in Figure 1. Based upon the theoretical approach for UCs' scenarios selection, the user and stakeholders' wishes, the Driver/Rider state model and an exhaustive review of the literature, a methodology has been applied to reach the final scenarios for each Use Case.

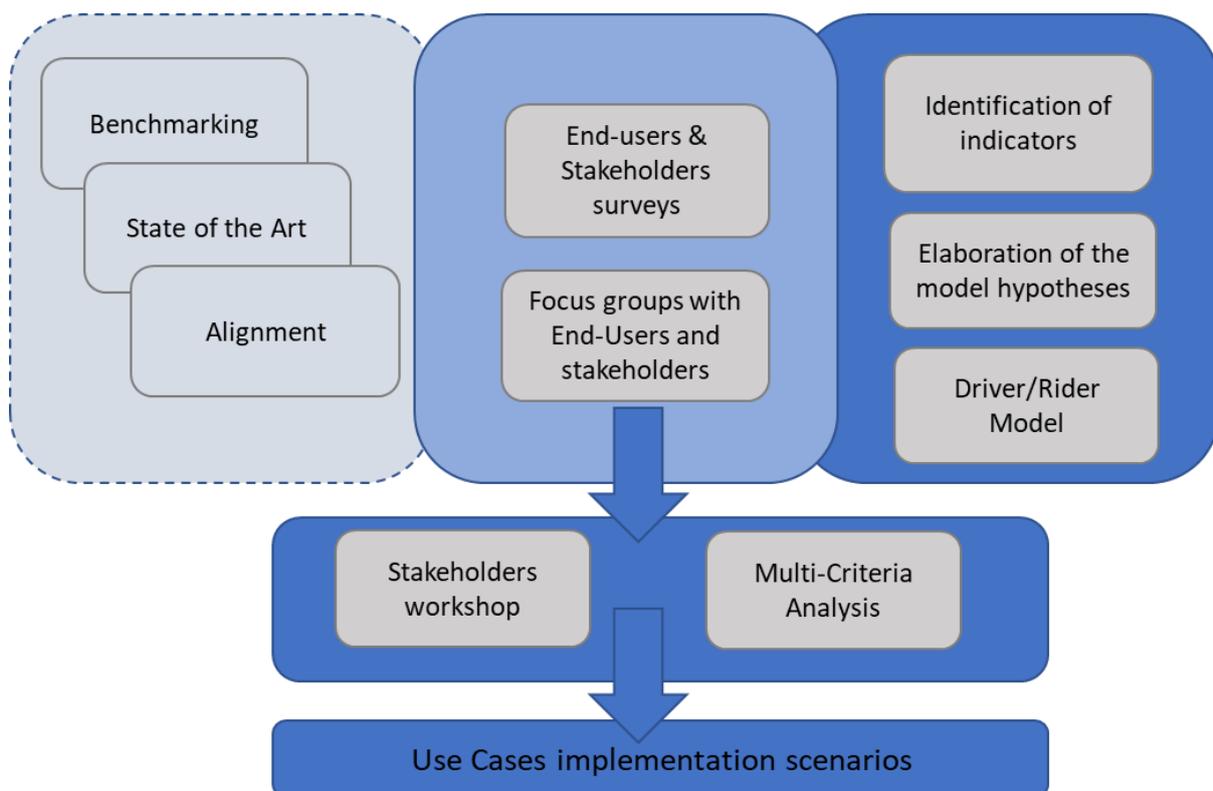


Figure 1: Overall methodology used in ADAS&ME to define the use cases scenarios.

2.1. Indicative UC

The project started with indicative UC that were described at the beginning of the project. Table 1 presents an overview of our UC. Those represent all vehicle types: truck, electric vehicle, passenger car, motorcycle and bus.

The UCs represent situations in which the interaction between the user and the vehicle could be improved by the introduction of automated systems based on driver/rider state.

Table 1: Use cases overview per vehicle types

Use cases	Illustrations	Description
Attentive long-haul trucking		Anna is a truck driver. An automated driving system will enable her to relax during her long working hours and ensure that she is more refreshed when she needs to take over the driving task. Her truck communicates with her when it is time to hand over control to her.
Electric vehicle range anxiety		Paul is driving an electric car. He feels anxious about whether he will reach his destination within the available range. By means of information visualisation and rerouting propositions provided by the car, Paul will arrive safe and relaxed at his destination.
Driver state-based smooth and safe automation transitions		Niki, a car driver, is offered the option of automated driving when the vehicle detects she is stressed and sleepy. When Niki is again deemed fit to drive, the vehicle will ask if she wishes to take back control.
Long range attentive touring with motorbike		Bruno is riding a motorcycle capable of checking whether he's incapacitated (e.g. stressed) by monitoring his body. His vehicle is able to warn him and propose a suitable rest stop, or even limit its own performance, to help ensure that Bruno will arrive safely at his destination.
Passenger pick-up/drop-off automation for buses		Peter is driving a bus and would benefit from support at the bus stop during a stressful and safety critical situation. At the bus stop, the system takes over and Peter is able to relax and focus on his passengers. Leaving the bus stop, the system checks that Peter is fit to drive and hands back control to him.

2.2. End users survey

The construction of the survey was based on ADAS&MEs' partners input through workshops and meetings. The survey consisted of three parts: background information of end users such as age, gender, driving license; broad questions regarding end-users' opinions about automation in vehicle and experience of systems and use case specific questions focused on their relevance. The final survey was translated from English to French, Italian, Spanish, Greek, Swedish and German. In parallel, the short stories describing the UC were developed, along with exemplifying illustrations.

The online questionnaire was developed using the software SoSci Survey (Leiner, 2014) and was accessible online for three weeks starting on January 16th, 2017 and closing on February 8th 2017. The truck and bus UCs were open one more week to collect more responses from truck and bus drivers. The participation to the survey was open to the public world-wide and the link to the survey was available on ADAS&ME website and spread via our networks and social media. The ambition was to make it available to a broad category of drivers who potentially cover a broad opinion regarding the survey themes. Descriptive analysis of the data was performed with help of

IBM SPSS version 22.

3. Results

3.1. General background

In total 1094 persons answered the questionnaire. They were aged between 18 and 85 years old and 32% were women. Answers were received from Sweden (30%), France (17%), Germany (12%), Spain (10%), Switzerland (9%), Italy (9%), other European (9%) and other non-European countries (1.5%). Table 2 indicate the number of answered collected by UC.

Table 2: Type of vehicles driven by the survey respondents (only one answered allowed).

Vehicle driving type	Frequency	%
Truck	70	6.4
Electric passenger car	19	1.7
Passenger car	834	76.2
Motorcycle	152	14
Bus	19	1.7

About 75% of the respondents were positive to get support by automation during driving. However, concerns were revealed by almost half of the respondents (43%) regarding ownership and use of the data. The guarantee of privacy/anonymity was the main concern as they did not want to allow the data to leave the car, or if it did, they wanted the transmission to be secured. They also expressed worries about the risk of hacking and that data is passed on to authorities. Regarding ownership of the data, 60% wanted to keep ownership of their data. Some respondents would allow sharing some data if they knew to whom and what data. This data should then be anonymous, for research, reparations or after crashes. Some respondents were interested to sell data for reduced/free service fees or other advantages.

3.2. Use case specific results

3.2.1. Attentive long-haul trucking

When asked on a five-grade scale (from not at all “1” to “very positive “5”) how likely end-users were to recommend this scenario, the answers suggested that they were slightly likely to suggest the function ($M = 3.13$; $SD = 1.63$). Users’ answers could be divided into two groups: “not at all” (mode value 1) and (very) positive. End users were also asked what they would like to do when automation is active (Fig. 1). Truck drivers were mostly willing to check their route and talk on the phone with others. About 40% would like to rest but stay in their seat, less than 20% were willing to rest/sleep in their bed during automation.

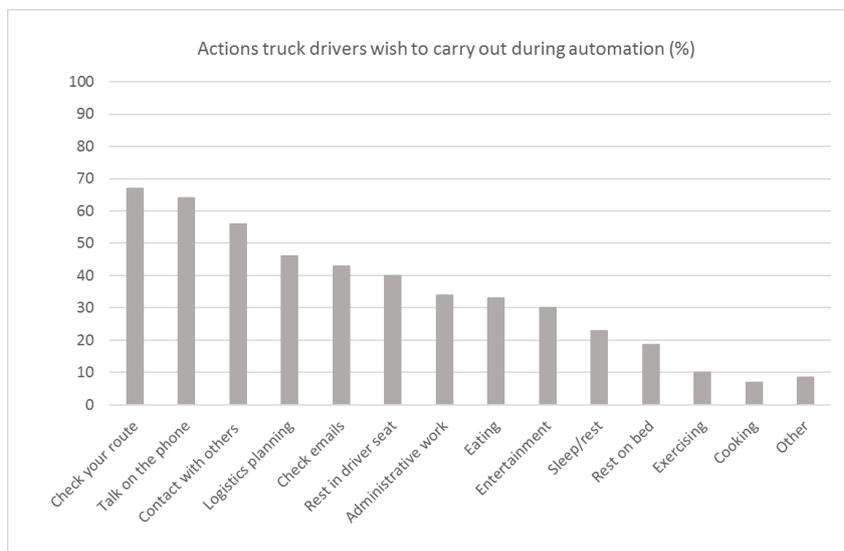


Fig. 1 Actions that trucker drivers are willing to perform during automation.

Regarding the daily driving tasks, drivers wanted the most to get support during traffic jam negotiation and highway driving. To get support in bad weather conditions and at night were also ranked high (Fig. 2).

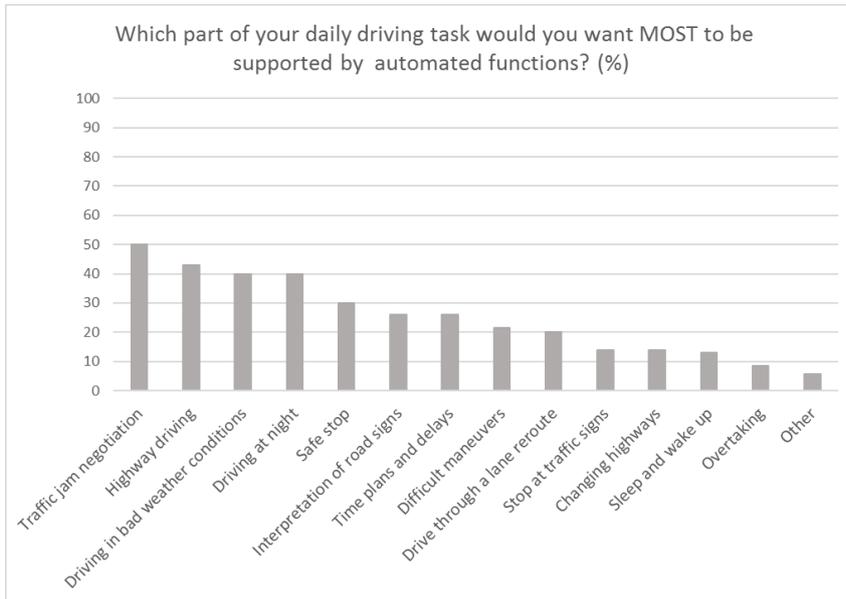


Fig. 2 Part of the daily driving where truck drivers want support.

3.2.2. Electric vehicle range anxiety

A large majority of respondents were willing to recommend the scenario presented in the UC (58%), contra 16% who said that they would not at all recommend it. EV drivers were asked what actions they would like to carry out when automation is active (Fig. 3). A large majority would like to talk on the phone (58%) and to make plans to decide about the eco-friendliest route (58%) to take.

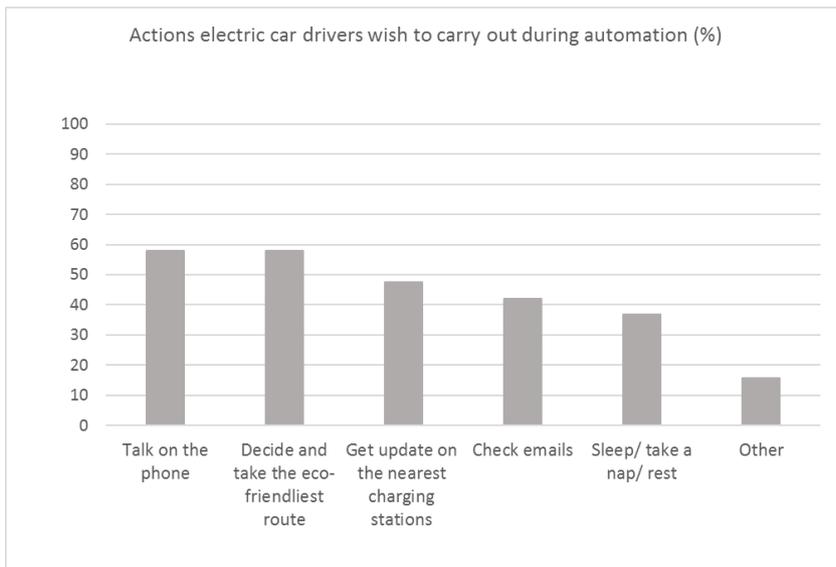


Fig. 3 Actions EV drivers are willing to perform during automation.

When it comes to what types of daily driving task the EV drivers wanted to get support from automated functions, how to plan for time and delays (69%) and support during driving at night (63%) were the most wanted (Fig. 4).

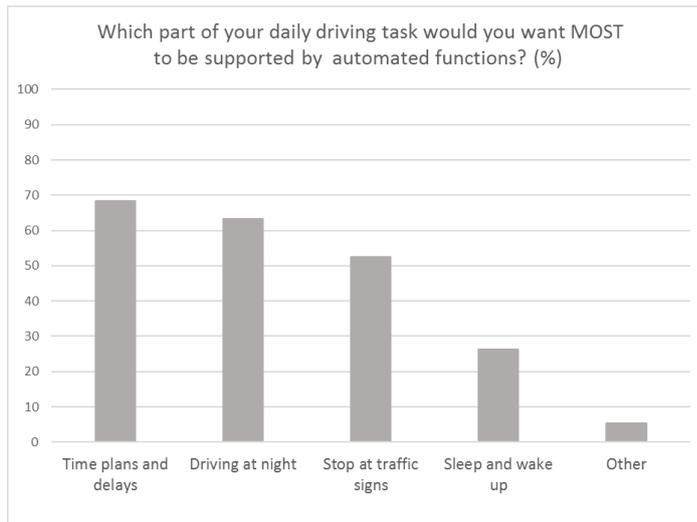


Fig. 4 Part of the daily driving where truck drivers want support.

3.2.3. Driver state-based smooth and safe automation transitions

This scenario split end-users equally regarding their willingness to accept automation. When asked how likely end users were to recommend this scenario, the respondents' answers were spread from "not at all" (18%) to "I will certainly do" (26%) ($M = 3.26$; $SD = 1.43$). The respondents were mostly willing to be supported to avoid collision (83%) which is a safety function (Fig. 5). About 68% of the car drivers wanted to be supported in heavy traffic situations with a type of "stop-and-go" function. A system to prevent sleepiness at the wheel was wanted by 65% of the respondents.

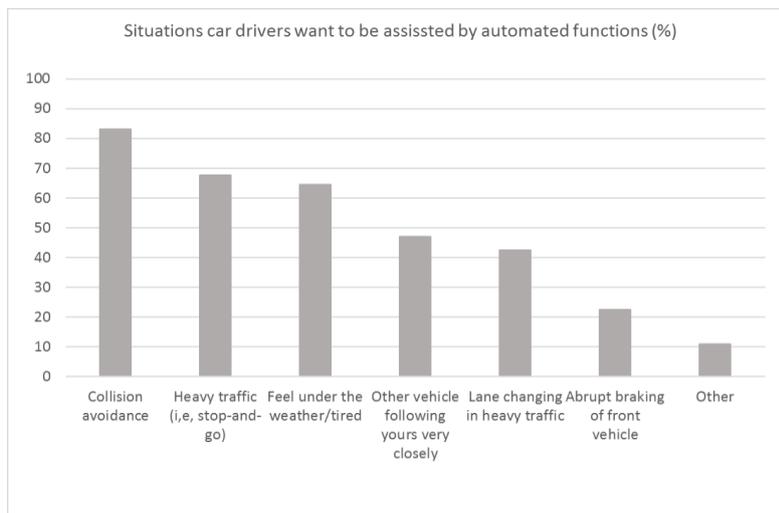


Fig. 5 Situations where car drivers want to be assisted by automated functions.

Respondents were asked about what part of the daily driving they wanted to be assisted under. The scenarios "search for parking" was selected by 56% of the respondents, going to work by 55% and "stop at traffic signs" by 34% of the respondents (18% responded others).

3.2.4. Long-range attentive touring with motorbike

When asked how likely end users were to recommend this scenario, the answers were split with about 30% of the respondents "not at all willing to recommend" this scenario and 26% who were "certainly willing to recommend". The riders were asked in what situations the automated functions should take over the control (Fig. 6). Riders want to get support mostly when they feel tired (48%) and when the weather is changing (45%). They would like support during heavy traffic situation with a type of stop-and-go function (38%).

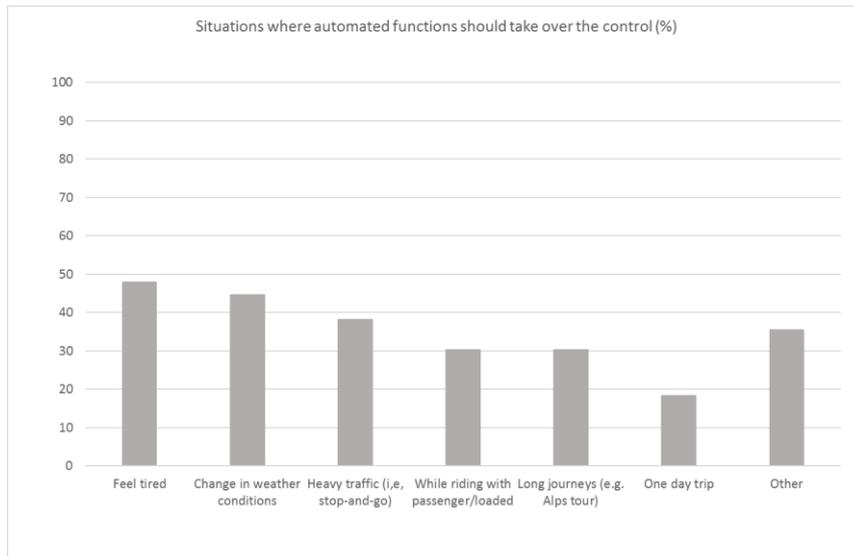


Fig. 6 Situations where automated functions should take over control for riders.

3.2.5. Passenger pick-up/drop off automation for buses

In total 19 answered the questionnaire. When asked how likely end users were to recommend this scenario, the answers suggested that they were slightly likely to suggest the function ($M = 2.79$; $SD = 1.27$). There were two groups of respondents: the one answering “not at all” (21%) and the ones who were little positive to recommend (31%). End users were also asked in what situations they would like to be assisted by automated functions (Fig. 7). They were mostly willing to get support for ticketing (58%) and to check passengers (48%). Observe that only 16% of the bus drivers wanted to get support to rest during driving.

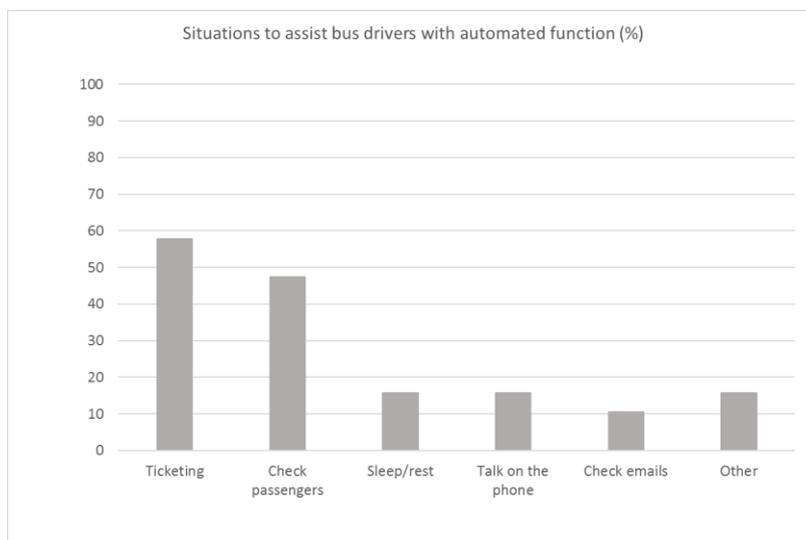


Fig. 7 Actions that bus drivers are willing to perform during automation.

When asking when bus drivers wanted to be supported during their daily driving, 68% answered for ticketing, 58% answered at the bus stop and 42% at stop sign.

3.3. Degree of control and information wanted by all use cases

Overall for all UC, the drivers/riders were positive to get support by automated functions as long as they could take back control of the vehicle at any time (Fig. 9). This was most important for truck drivers, bus drivers and

drivers of passenger cars. Riders and electric car drivers seem to be more interested to get information about the situation and to receive a warning rather than the vehicle takes over control. Overall, interest to have a vehicle which “take over control from you completely” was mild with a response rate between 4% for the riders and around 30% for electrical vehicle drivers.

The truck/bus/car drivers were willing to let the vehicle take over control in urgent situations, but they wanted to be able to take control back at any time (67%). They were more positive to get informed and warned by the truck (60%), rather than having a truck taking over control completely from the driver (19%). About 30% of all drivers appreciated to get feedback from the truck regarding their physical conditions.

A cornerstone for ADAS&ME is the driver/rider monitoring to adapt the automation. One of the question asked to end-users was whether receiving “feedback on your physical condition and the way you feel” was attractive to them or not. Around 30% of the respondents felt positive about receiving information about their physical condition. The most enthusiastic groups of end-users were riders and (electric) passenger cars. The less enthusiastic were professional drivers, bus and truck drivers.

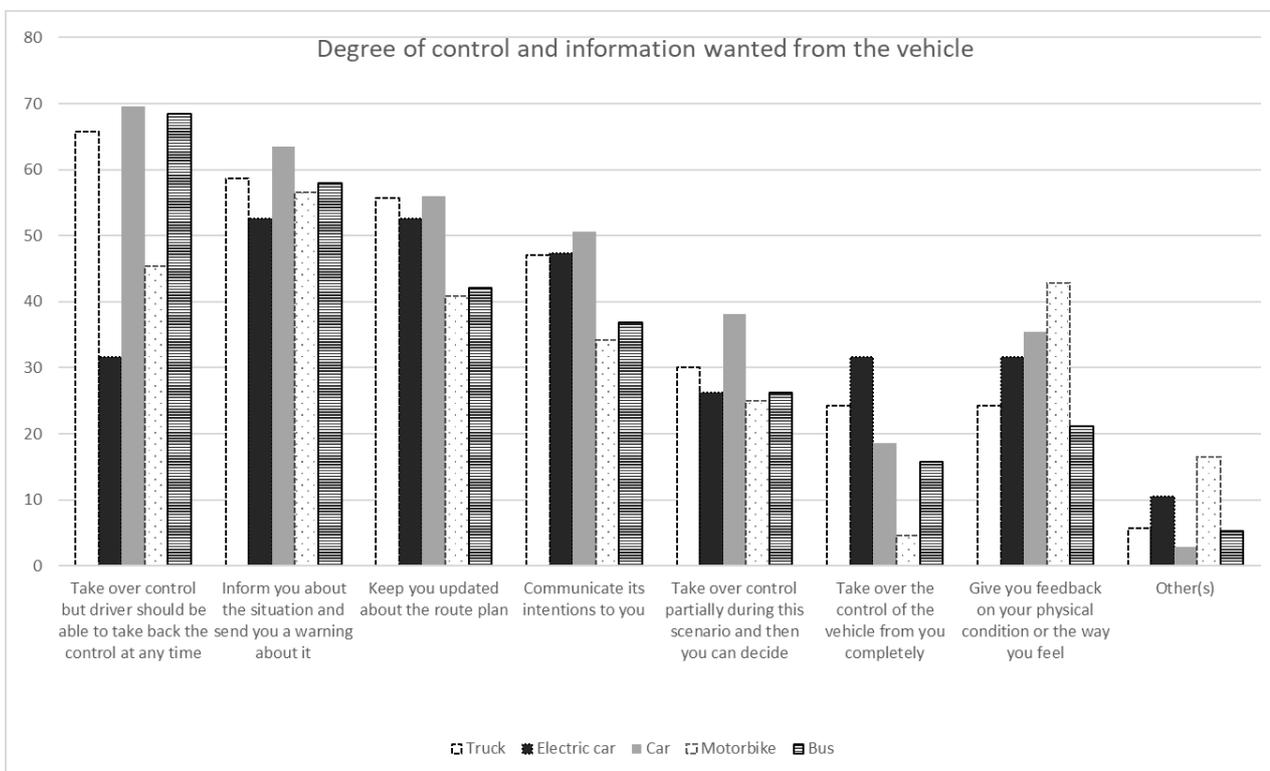


Fig. 8 What degree of control and information is wanted by ADAS&ME end-users in their vehicle

4. Use cases tuning

Based on the results from the survey a summarization of the conclusion is presented in Table 3:

Table 3: Results' implication for use cases

Use cases	Implications for the UC
Attentive long-haul trucking	Drivers will most likely stay in the driver seat even for resting/sleeping but the design should allow other positions New ranking of information that the drivers want to receive during automation-based on situations and daily driving scenarios in which the

	<p>drivers want to be supported</p> <p>The vehicle should be in control during automation but allow the driver to take back control at any time</p>
Electric vehicle range anxiety	<p>Scenarios to include for automation is “talk to the phone”, “decide and take eco-friendliest route” and “update you on the nearest charging stations”</p> <p>Automation will be proposed when the driver needs to select a proposed solution (e.g. re-routing alternatives), this will impact safety</p> <p>The charging station booking will be added to the scenario, this will impact comfort</p>
Driver state-based smooth and safe automation transitions	<p>Automation should check if driver is able to perform manual driving</p> <p>Avoid unintentional deactivation of the automation</p> <p>Automation should regulate emotion so that the driver is in an adequate state to take over control</p>
Long range attentive touring with motorbike	<p>Automation should be considered when riders are tired, in particular in case of variable weather conditions.</p> <p>Automation acceptance is in line with literature: riders are generally sceptics and potentially open only in emergency cases. Therefore, automation functions should not be continuously invasive.</p> <p>About the HMI, feedbacks are quite conflicting: riders ask for a simple, intuitive and not-overloading HMI, but at the same time their request is of a combined feedback (e.g. visual and haptic). For this reason, there is the need of finding a good compromise through fine tuning to deliver multisensorial feedbacks/interaction without generating excessive cognitive load.</p>
Passenger pick-up/drop-off automation for buses	<p>Design automation to support ticketing and all tasks performed at the bus stop</p> <p>Automation should support the bus drivers until (s)he decided whenever to take the control back</p>

5. Discussion

Automated vehicle technology has been highlighted as a possible solution to improve is road traffic safety in the future. To insure relevant and accepted automated functionality in future vehicle, several surveys have collected future user opinions worldwide (Daziano et al., 2017; Hohenburger et al., 2016; Kyriakidis et al., 2015; Schoettle & Sivak, 2014). Within the ADAS&ME project, the focus was on the driver monitoring part as a prerequisite to implement automation. About 1000 bus/truck/(electric)car/motorcycles drivers from a dozen European countries answered the on-line survey aimed to gather opinions and tune our pre-defined use cases. A majority of the drivers/riders was positive to get supported by an automated vehicle. Mostly they wanted to get support at any time by the automation but they also wanted to be able to get the control back whenever they judged to be appropriate. The innovation part of ADAS&ME is to implement automation based on driver state monitoring and to support incapacitated drivers on-road.

Overall survey results show that respondents see a gain from automation to decrease the task demand and to increase their opportunity to perform other tasks while in the vehicle. Truck and car drivers wish to talk on the phone and have contact with others while bus drives see automation as a way to improve their working conditions. Motorcycle riders were the most sceptical towards automation. The driver/rider monitoring part and the feedback in term of information to the driver/rider was appreciated by all the respondents and mostly by motorcycle riders since their awareness of their own physical conditions can be low, especially during long rides, due to physical and environmental constraints. These results indicate that respondents see a private gain of being monitored and value it. At the same time, some concerns were identified. Major concerns were twofold. First concerns regard the ownership and use of the data. Second concerns relate to security issues with risk for hacking and the potential involvement of authorities. These two main concerns have been reported earlier in several surveys (Schoettle & Sivak, 2014; Kyriakidis et al., 2015). Kyriakidis et al. (2015) performed a web-based survey done among 5000 participants from 109 countries where they found most concerns about hacking and misuse regarding transmission of the data. Survey participants perceived their data as sensitive information and are doubtful to share them.

Those issues need to be addressed by the legislation worldwide to minimize their consequences. Moreover, there is also a need to inform and communicate to future users how the automated vehicle will handle security and legal aspects. This is even more actual since the ADAS&ME automated vehicle will handle sensitive and private driver state data.

In conclusion, the ADAS&ME end-users surveys allowed to receive feedback from a thousand of end-users mostly across Europe. This was important as the use cases could improve from the feedback, but also to address the development of future automation in a human centred way. Next steps are to continue the development of adaptive ADAS, especially regarding HMI. The legal issues highlighted in the present survey will be addressed by lawyer inside the consortium to come up with innovative solutions.

6. Acknowledgements

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The sole responsibility for the content of this paper lies with the authors. It does not necessarily reflect the opinion of the European Union. Neither the project nor the European Commission are responsible for any use that may be made of the information contained therein.



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