Towards understanding the development of driver’s mental model of a Lane Departure Warning system while driving

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Abstract
Like all man-made artifacts, Advanced Driver Assistance Systems have certain limitations beyond which they cannot function properly or work at all. The users in the driving domain have diverse backgrounds and it is likely that many of them start interacting with the technology without having gained detailed knowledge, such as by reading user manuals. This study explores whether drivers with only minimal knowledge of the Lane Departure Warning system can recognize the system's speed threshold and update themselves about this in a dynamic driving environment. Since drivers are not always single-mindedly focused on driving so participants were divided into two groups. Group 1 subjects performed only the driving task, while Group 2 was prompted to carry out a secondary task in addition to the primary driving task. Our investigation allowed us to estimate the effects of drivers’ minimal mental model of the system working due to lack of sufficient knowledge concerning its capacities upon their 1) learning from experience and 2) situation awareness. It was assumed that the demands of multitasking would impair the driver's ability to observe the system’s state and delay the mental model improvement process, compared to a setting in which driving was the only task. Experiment results using a driving simulator have been presented. The results revealed that the number of the drivers, who did not become aware of the operating condition of the LDW system, was quite high for both groups regardless of the nature of their tasks. It had been deduced that the users’ preconceptions and expectations due to their limited knowledge about the capacities of the technology, could make them rely on the system to alert them in different situations even when the system was not operating. Hence, these factors can not only adversely affect the social benefits associated with ADAS, but also the acceptance and usability of these systems.

Key words: Advanced Driver Assistance Systems (ADAS), Lane Departure Warning (LDW) system, Systems boundaries, Mental model, Safety and situation awareness (SA)

1. Introduction

Human beings are in a constant struggle against time to conceive, plan, and optimally transform resources to make more and new tasks possible. Advanced Driver Assistance Systems (ADAS) are an outcome of such attempts and are getting increasingly popular. These technology-based support systems are designed to 1) mitigate the impact of variation in human performance by improving situation awareness; 2) augment safety under normal as well as time-critical situations; 3) enhance traffic efficiency; and 4) decrease driver workload.

The most common ADAS in current automobiles are Lane Departure Warning (LDW) system / Lane Keeping Assistance (LKA) system, Blind Spot Warning (BSW) system, Distance Control Assist (DCA) / Forward Collision Warning (FCW) system and Full speed range Adaptive Cruise Control (ACC) system with Brake control.

ADAS are adept at detecting changes in vehicle behavior and the surrounding environment, and respond promptly. Nevertheless, like the people they are designed to assist, they have operational limitations and boundaries. Depending on the circumstances, they need a few or more than a few conditions to be satisfied to come into play. From a technical
point of view, such operational margins are obvious and expected in any system. However, since the domain of automobile holds a tremendous variety of users, the working conditions of a given system may be unexpected and not easily perceived by normal drivers. Unlike personnel involved in aviation, marine, process industries, or power plants etc., the typical driver has almost no expertise or training on the systems. Compared with the above mentioned areas, no doubt, the sophistication of automation in automobiles is far less, but still not that relaxed. Of course, detailed and accurate information about the systems is always provided in owner’s manual but most drivers are unlikely to have read these thoroughly. Accordingly, drivers typically construct very general and naive mental models of the working of the technology they employ, usually on the basis of partial information acquired, for example, through advertisements, salespeople, or other persons. Thus, there exists a high likelihood of considerable gaps between the actual working scheme and the driver's mental model of the assistance system. Insufficient knowledge of the system’s operational capacities is a potential threat to safety, because it degrades the driver's awareness and judgment of surrounding conditions including the status of the assistance system.

According to Craik, as cited by Andersson (2010), mental models are ‘small scale models of reality’ which human beings use to reason, anticipate and explain events. These models are continuously updated and modified as an individual gains experience. In the context of the use of ADAS, drivers have opportunities to learn how their mental model of a system differs from actual system behavior, though clues may be elusive. This point spurred us to ask the following questions:

- If an ADAS user’s general mental model lacks essential aspects of the system's working scheme, can they nevertheless recognize, learn and correct errors in their model using only their driving experience, without any kind of explicit feedback?
- Since the act of driving usually occurs together with other activities, does the amount of cognitive resources a user spares for activities other than driving influence their ability to learn about the system?
- Should the information about the systems be confined to user manuals, and let the drivers learn on their own, or these smart technologies call for clear elaboration and training for attaining genuine safety?

This paper documents our attempt to explore these questions through a driving simulator experiment. A Lane Departure Warning (LDW) system with a hidden speed threshold, set to differentiate system behavior, was employed as a model assistance system to be learned by naive users. We therefore investigated whether drivers could recognize the speed threshold of the LDW System and update their mental models of the system’s operation while driving in a dynamic environment. An additional objective of this study was to elucidate the effects of technology use, with insufficient knowledge, on driver-system interaction, situation awareness and safety. Here, the meaning of ‘situation awareness’ is not confined to a driver’s awareness of the surrounding conditions, aided/ unaided by the system, but extends to knowledge of the system’s state itself, i.e., automation awareness.

Our study involved two groups of participants, Group 1 and Group 2. The first group performed only the driving task, while the second group executed a secondary task in addition to the primary driving task. The purpose of imposing a secondary task was to introduce a multi-task setting, since activities such as operating navigation system, operating hardware switch controls, conversation, cognition, planning and so on are carried out commonly. Our aim was to examine the impact of multitasking on the development of mental models and assess how such activities alter a driver’s perception, compared with situations in which driving is the only task. These schemes enabled us to appraise that how learning from experience is affected when a driver's cognitive, visual, auditory and physical resources are broadly distributed and preoccupied with tasks other than driving. The secondary task in our study demands drivers to share their cognitive, visual and physical resources; sharing of auditory resources was not required.

We assumed that a multitask setting would affirm that in dynamic driving environments, where drivers are not exclusively focused on driving, their ability to observe an assisting system's state fluxes would impair, which negatively affects their awareness and hence delays mental model improvement process. Consequently, it was hypothesized that Group 1 participants would be better at recognizing the LDW system speed threshold and would more easily improve the mental model of its operation.

Some research in the literature has discussed understanding problems and mode confusion in drivers using ACC (e.g., Furukawa, et al., 2003; Horiguchi, et al., 2010; Goodrich and Boer, 2003; Ohno, 2001; Marsden, et al., 2001; Larsson, 2012, etc.). However, to the best of our knowledge, no research has yet considered the response of ingenuous users of ADAS, under the influence of their impaired or prejudiced mental models about it. The implications of drivers’
prejudiced mental models in this interaction and their natural trends towards apprehending the operational satisficing conditions of the systems have not been investigated in depth. This paper aims to address these issues and makes an empirical contribution to ADAS research.

2. Driver’s awareness with ADAS

In human-machine systems, humans are using, controlling and supervising technological artifacts employing their motor skills, sensory properties and cognitive capabilities (Wieringa and Stassen, 1999). Machines are used with an expectation that they will extend human abilities to attain goals more proficiently and with less effort (Inagaki, 2008). ADAS have also been devised to reinforce driving operations, especially in the context of situation awareness and safety, as research and investigation has shown that driver inattention is a major contributor to inner city and highway crashes.

The design principles for ADAS have been explored extensively over the past decade or more (e.g., Goodrich and Boer, 2000; Abe and Itoh, 2008; Inagaki, et al., 2008; Bellet, et al., 2009; Brookhuis, et al., 2001; Meng, et al., 2004; Van Der Heijden and Van Wees, 2001; Thalen, 2006; Piao and Mcdonald, 2008; Amditis, et al., 2010, etc.). Automobile manufacturers and researchers are investigating that which function should be automated, and the extent to which such automation is possible. The modes and timing of information flow between driver and assisting technology are under high consideration, because for ensuring SA the collaboration between the two agents is eminently requisite.

Endsley (1988) has defined SA using a three-level construct, i.e., perception, comprehension and projection of elements in an environment within a volume of time and space. Hence, ADAS are intended to help drivers perceiving, comprehending and projecting the situation in a timely manner while a vehicle is being driven. The SA model in Dynamic Decision Making by Endsley (1995) and other studies (e.g., Heymann and Degani, 2002; Parasuraman, et al., 2000; Stassen, et al., 1990; Johansson, et al., 1994, etc.) show distinctly that these levels have direct/indirect affinity to the factors like preconceptions (mental models and expectations), abilities, experience, and training. When automation is introduced, these individual factors, among others, can contribute considerably to "changes in vigilance and complacency with monitoring” (Endsley and Kiris, 1995), in the users of the systems.

During the act of driving, the driver’s basic situation awareness is what he/she experiences without the aid of any assisting system. This basic information acquisition and data integration scheme of the driver, which is based on conventional driving tactics and his/her own way of exploring the environment for clues, becomes divided into subclasses upon insertion of smart assisting systems as shown in Fig. 1. If a driver starts using the system and his/her own mental interpretation of its operation does not functionally match the target system’s behavior, this will affect not only the individual classes of awareness through the system and awareness of the system, but can substantially deteriorate the individual awareness. Because the assistance, that an automated systems provides, can and will lead to an attitude of reliance/over reliance on them (Wiener and Curry, 1980). This influence can further weaken the decision making, as well as inhibit the execution of appropriate actions and ultimately reduce safety.

![Figure 1: Classes of Situation Awareness (SA) with ADAS](image-url)

The driving environment is usually not only less predictable, but also the margins of errors are very small. Thus, in
a multi-task dynamic driving environment, that even includes an ADAS, drivers’ awareness and attentiveness to system’s state remain doubtful. The time required for a driver to develop an understanding of ADAS functioning through experience, the succinctness and accuracy of this understanding, and the degree of safety enhancement that the use of the system might provide, are all unknown. However, the direct/indirect influence these general mental models can have on drivers’ cognitive and physical behavior can be anticipated, which demands attention and is the focus of this research.

3. Lane Departure Warning (LDW) system

A Lane Departure Warning (LDW) system helps prevent lane departure due to driver inattention or erroneous estimation of lane markings/boundaries. Vehicle's position and direction in a lane is analyzed after the detection of lane markings on the road, using a camera as a sensor, and the possibility of lane departure is calculated. Warnings are issued using sound and visual displays, and in some cases also haptically (Owner’s manuals 2010; 2011; 2012).

The LDW system requires certain conditions in order to operate. In most vehicles marketed by different companies, the LDW system remains in standby mode until a speed of 50 or 60 km/hr is reached. Conditions of rain or snow, fog, dusty wind and sudden changes in brightness (due to sun, headlights etc.) may prevent appropriate system operation, and operation is also problematic on roads with sharp curves, roads with multiple or dim markings, and roads with lanes that are unusually narrow or wide. The system stops working when the vehicle is travelling close to a vehicle in front that obstructs the camera’s detection range. When the LDW system cannot function normally, its operation is automatically cancelled. When the system is in operation, it is required to avoid excessive or sudden steering maneuvers, etc. The conditions for operations are more or less the same regardless of the manufacturers (Owner’s manuals 2010; 2011; 2012).

4. Experiments

4.1 Apparatus

To provide a highly realistic driving environment, PreScan® software version 6.1.0, was used for ADAS simulation in this research. The driving simulation environment was rendered from a first-person perspective and displayed on three 30-inch monitors located in front of participants, to replicate an immersive driving experience. Figure 2 presents the setup of the driving simulation. The simulated vehicle was equipped with a LDW system and controlled with a Logitech MOMO Racing Force Feedback wheel, brake and accelerator pedal, with automatic gearshift. The steering wheel could provide haptic feedback.

It is a matter of fact that the validity of the simulated environment is always restricted and debatable, but we find it necessary to inform that the PreScan® software has been specifically designed for ADAS simulation. Its use by different research labs across the globe, and its recommendation by the automotive company employee not only made us to select it for our study purpose but to be unambiguous for the obtained results as well.

Laptop computer running PsycoPy2 (Psychology software written in Python) was utilized to provide subjects with a secondary task when they were driving a simulated vehicle.

Fig. 2 Experimental setup
4.2 Participants

Twenty-four participants (3 female), aged between 21 and 40 years, took part in the study. All participants had a valid driver’s license and at least one year of driving experience, but none of the participants had an experience of driving a vehicle equipped with the LDW system. More than half of the participants had heard about this system and the rest were given commonly available information about it. No detailed written or verbal material about the operation of the system was provided to the participants. This was done to replicate a situation where a driver starts interacting with a new on-board technology while lacking sufficient knowledge about it.

4.3 Design and procedure

A simulated two-lane freeway, the starting point of the experimental driving setting, was created which merged into a three-lane highway environment. Figure 3 presents a top view of the driving simulator test track. Road signs were used to alert drivers to speed limits and for demarcation of road segments. The initial two-lane road had speed limit of 40km/hr, the curved road section used to enter the highway had 30km/hr speed limit, while the highway speed limit was 100 km/hr.

In our experimental setup, the Lane Departure Warning system starts operating at a speed of 50 km/hr. A small graphic area located in lower portion of the central monitor screen was used to display speed and present warning text, i.e., “departing left” or “departing right”, indicated as Region A in Fig. 2. Figure 4 shows an enlarged view of this area. When warnings were issued, the warning text blinked in red. Warning was also simultaneously issued haptically through the steering wheel using rapid vibration.

Also present in the simulation were a number of other automated cars, moving at set trajectories to imitate a dynamic traffic situation. The automated cars could change speeds and lanes, so drivers were asked to remain vigilant and avoid accidents. All participants received an explanation of the general setup and gave informed consent. Once the participants were familiar with the equipment, they completed a practice session during which the LDW system was switched off.
The participants were informed that the actual experiment would consist of five separate trials and that they would be given a questionnaire in three parts: first at the beginning of the experimental session; second at the end of each trial; and third at the end of the completed session. They were told that there was no time restriction for completing a trial; however speed limits should not be ignored. The participants were randomly divided and assigned to two 12-persons groups. The participants in Group 1 performed only driving task while those in Group 2 performed a secondary task along with the primary driving task.

In the secondary task, several three-digit numbers were displayed on the laptop screen positioned beside the large monitors. Participants were asked to respond to a number if it was 130 or less, or 170 or more, by pressing the laptop’s space bar. During each trial for Group 2 participants, the secondary task was presented for 48 seconds, but the starting time of this interval was different for each trial. The motivation for having this particular setting for the secondary task was to compel subjects to share and distribute their cognitive, visual, spatial and physical resources, and to have dynamic time-sharing performance. We wanted to determine if the time sharing characteristics of two tasks scenario and driver’s preoccupied resources influence a driver’s ability to learn from experience, i.e., develop a functional mental model of the LDW system.

5. Results and discussion

5.1 Participants’ original mental models

The questionnaire given to the participants at the beginning of the experimental session asked them: if they know what the Lane Departure Warning System is, then state its function. The motive for asking this question was to ensure that subjects had an internal representation of the system’s working at that stage. Their statements helped us to infer their mental models and then to categorize them. Thus, on the basis of the participants’ understanding of the events that trigger the LDW system operation in a vehicle, the mental models were sorted into three classes A, B and C as presented in Fig. 5, where

\[
\begin{align*}
\alpha &= \text{System is engaged and active for full speed range} \\
\beta &= \text{The vehicle touches a lane boundary} \\
\gamma &= \text{The vehicle gets inside the lane boundaries} \\
\beta' &= \text{The vehicle crosses the lane boundary} \\
\beta'' &= \text{The vehicle deviates from the center of the lane} \\
\gamma' &= \text{The vehicle returns to the center of the lane}
\end{align*}
\]

![Fig. 5 Participants’ mental model classes for the LDW system state transitions](image)

It is evident from Fig.5 that users’ basic mental models about the operational speed of the system were lacking any boundaries. Once the LDW system was engaged, it was assumed that it is active for full speed range and there would always be warning by it when the conditions, they thought, were satisfied.
The total number of participants in each class, and the number of subjects in these classes with respect to the task performance are shown in Table 1.

Table 1 No. of subjects in each class with respect to task performance

<table>
<thead>
<tr>
<th>Mental Model Classes</th>
<th>Group 1 (Single tasking)</th>
<th>Group 2 (Dual tasking)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>B</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>C</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

5.2 Mental Model improvement through LDW system experience

All the participants took approximately 300 seconds to complete a trial run. The results obtained through the experimental trials were as follows:

*Group 1*: Only 2 out of 12 participants became able to correctly recognize the speed threshold of the LDW system and update themselves. None of the other participants who performed the single driving task could detect the system boundary.

*Group 2*: In the second group, again, only 2 participants could discriminate that the system became active only after reaching a certain speed but according to them that threshold speed was 40km/hr and 60km/hr respectively.

The mental models the successful 4 drivers were having originally have been presented in Table 2, and Fig. 6 shows the model of the LDW system operation which successful participants (almost) acquired through their observation of the system while driving. The other 20 drivers remained stick to their initial mental models.

Table 2 Successful participants’ primary mental models

<table>
<thead>
<tr>
<th>Mental Model Class</th>
<th>Group 1 (Single tasking)</th>
<th>Group 2 (Dual tasking)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>B</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>C</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Fig. 6 Model of the LDW system operation
\[ \alpha' = \text{System is engaged} \]
\[ s = \text{Speed is 50km/hr or less} \]
\[ s' = \text{Speed is greater than 50km/hr} \]
\[ \sigma = \text{The vehicle is near or touching a lane boundary} \]
\[ \gamma = \text{The vehicle gets inside the lane boundaries} \]
\[ \gamma'' = \text{Speed has become 50km/hr or less} \]

Thus a total of 4 drivers out of 24 made it out. The high proportion of the unsuccessful subjects confirmed that the influence of the partial mental models is often so compelling, that it becomes hard for the user to jump out of fallacies. Users experience the phenomena, but they might not be able to learn from it because their impaired mental model does not help them observe it. During the experiment, the participants’ awareness level was tracked by asking them repetitively after every trial if, at any time during the trial, they doubted the working of the warning system. The unsuccessful subjects kept on saying ‘No’. Under the governing influence of their mental model that the system was capable of working at full speed range, they did not monitor it. When they did not pay any attention to the system behavior and remained passive observer, they did not recognize the discrepancies in their mental model and did not make improvements. The finding also answers the first research question that if an ADAS user possesses a minimal mental model of the working capacities of the system, then there exist considerable chances that it affects their situation awareness (SA) i.e., awareness on both environment and automation and detains their learning from experience.

### 5.3 LDW system behavior recognition opportunities

The logged data reveal that the 20 drivers who were unable to recognize the LDW system’s speed threshold nevertheless had reasonable opportunities to notice the behavior of the system. They did touch/ cross the lane markings at the speed below 50km/hr during their trials, but they didn’t notice the absence of the LDW alarm when doing so. Figure 7 presents the frequency of the left boundary/right boundary lane departures under 50km/hr speed for both successful and unsuccessful participants in the two groups in five trials.

![Fig. 7 Frequency of Lane departures under 50km/hr across participants](image)

Participant no. 2 and 21 from Group 1; participant no. 8 and 10 from Group 2 were those who recognized the speed threshold. It can be seen that all the participants had opportunities to learn system behavior irrespective of their driving styles and number of tasks being performed. It can also be perceived clearly that the 4 successful participants did not have ample lane departures to have more provocative exposure of the speed threshold to be proficient than other 20 subjects. In consequence, the reason the unsuccessful drivers couldn’t notice the speed threshold of the LDW system, was the prevailing mental interpretation they were having about its working. The mental image did not enable them to spare their resources for observing the system behavior. The factor unintentionally caused drivers to rely on the system...
to alert them of any unintended lane deviation. They couldn’t keep themselves aware of the happenings at the speeds below 50km/hr and ultimately couldn’t update their mental models.

Figures 8a and 8b show the driving pattern of one of the participants in a trial, chosen from among the 20 unsuccessful subjects. In Fig. 8a, the x-axis represents the elapsed time in seconds and the y-axis is the vehicle velocity in km/hr. Red line represents the threshold speed i.e. 50km/hr. Figure 8b shows distance to the right boundary and lane departure warning to elapsed time. The vertical blue bars represent the LDW system warning events at speed above 50km/hr. The test track was 6m wide, with the center at 3m, also representing the centered position of the host car. The road had a 0.5m zone at the left and right sides, the threshold distance, which is why the distance graph doesn’t extend beyond 5m. When the distance chart drops to zero, this indicates that the threshold distance was touched or crossed.

![Fig. 8a Velocity profile](image_url)

![Fig. 8b Distance to right boundary and LDW graph to time](image_url)

Figure 8b shows that the driver was touching the lane boundary during the time interval of 40–44 seconds and there is no warning indication. The speed during this time period is less than 50km/hr, depicted by a rectangular colored region in Fig. 8a.

### 5.4 Secondary task setting implications

The results were quite unexpected in the context of mental model improvement of the two groups of participants, corresponding to single task and multi-task scenarios. It was assumed that the number of the participants, who were performing the driving task only, would be greater at recognizing the LDW system’s speed threshold. The multi-task setting would delay the mental model improvement process in Group 2. But the numbers of successful and unsuccessful participants obtained were the same for both groups. The finding led us to affirm that if there is an inadequate mental model of the capableness of the system, then its influence on the driver’s observation and learning ability could be irrespective of the number of tasks being performed, and answered the second research question. However, in the event of improvement of mental model the accuracy of the recognition may be affected due to multitasking. As shown by results that the Group 1 successful participants did recognize the speed threshold more accurately than Group 2 drivers. Qualitatively speaking, the Group 2 successful participants’ mental model of the working of the system was developed, but strictly speaking, their models lacked precision in terms of the speed threshold value. Thus, in this context, our hypothesis was correct, namely that the ability of drivers to observe the system’s working margins when performing more than one task would be weaker compared to that of participants performing only the driving task.
Among Group 2 participants, again no big disparities were seen in the secondary task performance, as shown in Fig. 9. Participant no. 8 and 10 were the ones who recognized the LDW system speed threshold. The result demonstrates that the subjects who could not recognize the system's speed threshold were not distinctly better in executing the secondary task in contrast to the participants who recognized. The unsuccessful participants were not seemed to be concentrating more on the secondary task accomplishment. The number of right answers was high and more or less stable between all of them.

Fig. 9 Secondary task performance

Hence, the outcomes allowed us to appraise that the existence of the secondary tasks could not be the merely basis of impairing drivers’ observability, but their partial mental interpretations were among the reasons to undermine their perception and halt any development. These implications of users’ mental models cannot be ignored in ADAS implementation.

Despite the presence of other automated vehicles in our simulation, no collisions were recorded during both single and multi-task performances. Overall the subjects rated the system, when it is active, as an effective tool to maintain safe lane position.

6. Conclusions

The present study has considered one of the design boundaries of the LDW system, namely the speed threshold for on/off operation. From a technical and design point of view, this working condition can be anticipated as a very simple and easy to recognize system feature. But the findings tell us a completely different story, which verifies the fact that somewhere the designers are forgetting who the users are. Identification of the system boundary by only 4 drivers out of 24 is a quite clear indicative. It might not be exceptionally unreasonable to assume that in real-world scenario, this particular system limit can be naturally recognized in course of a few days’ driving. But if a user comes to believe that the system can work in rainy, windy roads, and the like, as he/she needs most assistance in such situations, the result may be an increased risk of accidents, rather than increased safety. Rainy days or snow, for example, cannot be awaited for learning from experience. Thus, the use of advanced systems in cars by drivers who lack necessary knowledge of the systems’ capacities threatens both situation awareness and safety.

The results of our experiments also reveal the point that the naivety and partiality of drivers’ mental models itself are powerful enough to impede the development of their mental interpretations of an advanced system. It can be seen that the number of the drivers who did not become aware of the LDW system’s operating condition for both groups was regardless the nature of their tasks. We observed that the users’ preconceptions and expectations, as well as the driving environment, could make them rely on the system to alert them of any unexpected situation even when the system was not operating. Hence, their observability and judgment can get impaired and they couldn’t keep themselves conscious of the on-going events. These factors can not only adversely affect the social benefits associated with ADAS, but in a broad perspective, acceptance of these systems too.

Although no collisions occurred during our simulations, such results could not, of course, be extended to actual operation. What is clear, however, is that the insufficient knowledge can undoubtedly influence a driver’s daily driving
behavior. There is a need to devise rules for proper verbal/practical communication of information about such systems from makers/sellers to customers, and ensure that these are followed. For realizing real safety and situation awareness, drivers should receive training in the operation of the advanced systems they can rely upon. It is unreasonable to assume that common people would ordinarily learn operational details by themselves, or that the knowledge thus gained would be accurate. Our study also suggests that the incorporation of electronic media inside vehicles, which could be used for quick guidance on systems operation, might be beneficial. As advanced automotive systems become more sophisticated, the need to reconsider and improve driver-ADAS interaction becomes increasingly important. In future research, we hope to explore methods that will make it easier for drivers to understand and develop accurate mental models of these systems before/while using them, so that automation surprises can be more effectively avoided.

Since the presented study is trying to address the problem that has very general grounds and which encompasses the subjects from almost all the spheres of life, so we purposely tried to remain more subjective to have original information. At this stage, the simple method has been employed to get access to the basic and original mental models of the user or prospective users of ADAS, and to verify that the problem exists. We believe that this strategy provides us the basis to lay down the requisites for better tools to understand the mental models of the ADAS users. We expect that the research scheme would enable us in future to create concrete and efficient methods for analyzing the factors that generate mental models and have their role in its development.

References


