PART III

Validation and Evaluation

10

The HMI of Preventing Warning Systems: The DESERVE Approach

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10.1 Introduction

Early '70s literature in traffic safety put into evidence how the majority of accidents is a consequence of human error. One of the pioneering work carried out in 1977 in the automotive domain [34] started from an examination of a large number of accidents and showed that more than 90% of them was determined by different kind of mistakes attributable solely to a human factor and rarely to technical and/or environmental failures.

This finding was confirmed in the following years also in other domains with very complex technologic contexts (i.e. avionic, railway, etc.).

It was realized that in the framework of the evolution of technical systems, the human element plays a fundamental role both as a governing factor and as a potential menace to safety. This concept paved the way for the modern preventive safety systems, wide known as ADAS (Advanced Driver Assistance System).

The experience carried out into the DESERVE project (Development Platform for Safe and Efficient Drive) was agreed by all involved partners to be beneficial for the extension of future ADAS. A key role in this process is played by the Human Machine Interface (HMI). Since ADAS systems cope with the driving task influencing driver's decisions or directly intervening in the driving maneuver, the issue of the driver's trust opens a crucial design problem, because the driver cedes a part of the control [30]. Low trust, resulting e.g. from an earlier experience of failure, can lead to disuse of the system [24]. Building and enforcing the driver's trust through a positive system experiencing depends not only on the proper functioning of the system itself (i.e. the capability of detecting some events) but also on the HMI design.

In order to create those positive experiences and avoid the disuse of ADAS, one has to understand the driver and his/her goals and motives while driving [13], together with the role of technology in supporting the driver in his/her task and in avoiding road accidents.

This chapter aims at exploring step by step the rationale behind the effective design of the Human Machine Interface for ADAS systems, giving the reader an outline of the role and scope of ADAS system. In next paragraphs, a particular focus on the role of humans and role of technology in the preventing of the road accidents is presented, along with the discussion of the importance of the detection of the driver's intention. Then an example of a whole HMI design process is presented. In fact during the DESERVE project the in-vehicle HMI for 17 functions (13 of them were ADAS) was designed and evaluated. This chapter will report to the reader how the HMI was conceived, including discussions on the role of ADAS in preventing imminent accidents and a short state of art on HMI design approaches.

10.2 Prevent Imminent Accidents: The Role of Humans, the Role of Technology

In general, the amount of accidents among the years is progressively decreased since the second half of the '80s [8]. This basically depends both from a strengthen in humans awareness on the accident causes, partly influenced by the evolution of studies in humans factors, but mostly this depends on technological innovation on vehicles. The history of such evolution which intends to show the relationship existing between the run-up of the accident and the technologies and functions for safety enhancement will be presented in the next paragraph.

10.2.1 From Passive to Preventive Safety

The first phase in reaching a higher safety degree on vehicles was due to the introduction of the so called passive safety systems, whose main purpose is to improve the driver conditions while an accident takes place. Indeed, the

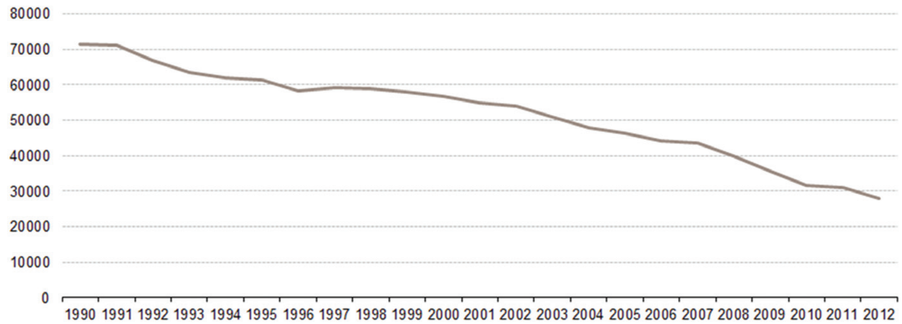

Figure 10.1 Total number of fatalities in road traffic accidents in Europe [8].

introduction of safety belts, airbag, etc., as well as the strengthening of the materials have significantly reduced the number of injuries and consequently the number of victims on the road. For instance, studies on the effectiveness of the seat belts were conducted since the end of the ’60s starting from Sweden [4].

The second phase was characterized by the introduction of active safety systems, which were intended to increase the safety of the driver when approaching a dangerous situation. In particular, this period dealt with the introduction of systems such as the ABS (Anti-lock Braking Systems), the ESC (Electronic Stability Control), as well as other functions able to intervene by minimising the impact in proximity of a potential dangerous situation and, hence, by avoiding the accident. For instance cars equipped with ESC were 22% less likely to be involved in crashes than those without, with 32% and 38% fewer crashes in wet and snowy conditions [19].

The challenge of reducing even more the number of accidents consists in allowing the development of the so called *preventive safety technology*, which is conceived to assist the driver when the risk of occurring a hazardous and critic situation is greeting higher. These technologies, named ADAS (Advance Driver Assistance Systems) are able to monitor the driving dynamics by introducing preventive features in support of the driving activity. In particular, driving safety will be fostered on the longitudinal axis of the vehicle thanks, for instance, to the frontal collision warning and adaptive cruise control systems. Driving safety on the lateral axis can be improved by systems like lane support and lane warning. The implementation of blind spot improves the safety on the rear spectrum indeed. The purpose of this approach is twofold: on one hand it is intended to guarantee an high level of protection on the road, almost as if the driver was stuck inside of a kind of “safety bubble”, as highlighted by some researchers when referring to the concept of "virtual safety belt" [31]. On the other hand, it aims at allowing cars to operate in coordination by implementing a scenario where the whole vehicles have high situation awareness capabilities. It is indubitable the effectiveness of the ADAS in driving safety, even most of them have not yet achieved a mature introduction in vehicle market but are still in the prototyping phase. Nevertheless, researches has shown that to an increase of the automation and accident prevention features included in the on-board technologies does not always correspond to increase of the driving confidence, especially if the drivers' expectations in vehicle technologies interaction are not fully taken into consideration by designers. On the other hand, a theory known as Peltzman effect [25] seems to show that an improvement of confidence due to effective automated safety support systems, even if they are only able to increase the driving monitoring scenario, could induce drivers in improving, for instance, speed, till to jeopardize the effectiveness of such systems.

10.2.2 The Role of Driver Model in ADAS Design

As aforementioned, Advanced Driver Assistance Systems (ADAS) have been implemented more and more in recent years in the automotive industry, in order to move from passive safety to preventive safety. In this context, through the driver models, a more complete understanding of driver's behaviour is expected to have the opportunity to enhance the road safety and to increase the driver acceptance of in-vehicle advanced systems, by designing ADAS that are more suitable to the drivers. As a practical example: the Lane Departure Warning (LDW) warns the driver when the left/right lane is crossed without using the indicator. However, blinkers are used only half the time before a lane change [18] and, therefore, the LDW might warn the driver in situations in which s/he is in full control of the vehicle (for example, during an overtaking without blinker activated), causing a nuisance to the driver. If this situation occurs frequently, the driver might get so annoyed by the system that might deactivate the LDW, eliminating the possible safety benefit brought by the system. If the human behaviour could be modelled more precisely, it would be possible to discriminate between an intentional lane crossing and (simply) an unintended lane crossing (with the LDW warning the driver only in the second case). Then, driver acceptance of the LDW could be increased. Similar examples could be found for other ADAS such as Forward Collision Warning (FCW) and Blind Spot System (BDS). Then, the driver intention detection module might be used jointly with other systems to warn the driver about risky behaviours or might be used for the communication with other ADAS. For instance, the lane change detection module could be implemented with a surrounding vision system or with a blind spot information system to prevent the driver from a dangerous overtaking manoeuvre (if an oncoming vehicle is spotted and, at the same time, a lane change intention is detected).

The Driver Intention Detection Module developed within the DESERVE project aims at modelling and predicting the driver's behavior at the tactical and operational levels of the Michon's model [20]. Among the maneuvers taken into consideration for the prediction of driver's intent, the most researched are the lane change, the turning left/right, the braking and the lane keeping. For the scope of the DESERVE project, the focus will be placed on the prediction of lane changes (and possibly of overtaking) with the final aim of improving the acceptance of ADAS. If a reliable lane change intention was developed, the warning could be issued only when needed: ADAS designed in such a way could increase driver's acceptance and reach a higher benefit with respect to road safety.

In the field of lane change intention detection, several researches have been already performed. One of the main authors on this topic is Salvucci. He applied the model tracing technique associated to a computational driver model to detect driver's intention to change lane [29]. Model tracing techniques were originally used for intelligent tutoring to predict students' possible next steps in problem solving. In the study of [29], data from the vehicle (steering wheel angle, accelerator depression, lateral position, longitudinal distance and time headway to a lead vehicle, longitudinal distance front and back, to vehicles in adjacent lanes) and from the environment (presence or absence of a lane to the left and right of the current travel lane) were used to build the model. Based on the information, the model calculates a desired steering angle and the accelerator position. The model performed well when tested both at the driving simulator and in the real vehicle, reaching a reliable detection of the maneuver after 1 second.

In a later research work [6], the authors developed and implemented a real-time lane change intent detection system which could go beyond the traditional offline implementation. The authors made use of information collected from the vehicle (steering wheel angle, yaw rate and blinker state signal), the Adaptive Cruise Control (distance to the lead vehicle, the relative speed, time gap to the vehicle in front and the difference between the current speed and the desired speed), the Lane Departure Warning (vehicle lateral deviation, lane curvature and vehicle yaw angle), the Side Warning Assist (occupancy and speed state within a critical zone) and the head position (head motion, head yaw and head pitch), adopting a time window of 2 second to trace the past events. A classifier based on relevance vector machines (RVM) was used for the lane change intent. The results show that, for a good prediction of the lane change intention, the inputs from the direct observation of the driver (head-viewing camera) are relevant and that the quality of the classification is improved (unreliable detections are beyond 3 seconds). In a later article [15], a multiclass Support Vector Machine (SVM) algorithm associated to a Bayesian filtering approach to predict lane change intention was used. The variables used as inputs for the algorithm were the lateral position of the vehicle (obtained from a lane tracker system), the steering angle, the first derivative of the lane position and the first derivative of the steering angle. The research was formulated as a multiclass classification problem with three possible outcomes: left lane change, right lane change and no lane change. On top of the multiclass classifier, a Bayesian Filter (BF) in order to improve the reliability of the predictions was used. The comparison between the SVM algorithm alone and the combination of SVM and BF shows that, in the first case, many false alarms were observed but the precision was increased by adding the Bayesian Filter, reducing average prediction times. Most of the lane changes are predicted almost 1.3 seconds before the lane crossing with a maximum prediction horizon reaching 3.3 seconds. The authors reported that further improvements might be brought by inclusion of other variables as the distance to the vehicle in front and the speed difference with the vehicle in front.

Overall, despite the knowledge acquired concerning the prediction of driver's intention to start a lane change, the topic is still interesting because the problem of lane change intention has shown to be extremely challenging. In particular, for having a more reliable prediction of driver intent, three aspects should be considered:

- to increase the precision of the prediction algorithms;
- to augment the detection time prior to the lane change;
- to decrease the number of variables to predict the lane change (not all the sensors used in the previous studies are available in common vehicles).

In addition, as pointed out by previous research [7], there are aspects which should be considered when designing a study to infer driver's intention prediction:

- type of inputs to be used: CAN data (steering wheel angle, pedal position, turn indicator), lane position sensor/camera (lateral lane position and standard deviation) and sensors for behavior data (head motion, eye motion foot and hands positions).

- type of algorithm to be adopted for the analysis: Support Vector Machines, Bayesian Nets, Hidden Markov Models
- material to be employed for the experiment: real vehicle (naturalistic or imposed) or driving simulator.

Regarding the first aspect, the results highly improve when measures of driver behavior are included, especially the head motion. However, this information is, usually, not available in common vehicles and, therefore, this feature should be further analyzed.

10.3 HMI Design Flow: The DESERVE Approach

In order to develop an HMI concept for ADAS capable of generating positive experiences during the driving task, a design workflow of 5 steps was used:

1. Collecting the state of art and last trends in the automotive HMI designing;
2. Defining three different HMI concepts;
3. Preliminary testing the three HMI concepts by a focus group;
4. Testing the best 2 concepts by a user test at driving simulator;
5. Defining the final concept.

The HMI was designed in order to allow adaptation strategies that takes into account the inputs provided by the driver model.

10.3.1 Different Approaches in the HMI of the Preventing Warning Systems: A State of Art in a Glance

From the point of view of the on-board human machine interface correlated to the different type of preventive accident systems, the evolution of HMI for ADAS could be clustered in three main phases.

It is possible to name the first era of preventive accident systems HMI as *warning era*. Most of the active and preventive systems above mentioned, which are not expected to be automatically actuated, are at the end a kind of *warning based systems* as they are aimed at increasing the driver awareness thanks to the support of technologies. The corresponding HMI is therefore based on alerts and aimed at delivering to the drivers immediately potential risks so to restore a safe situation for the driver.

The second phase coincides with an important transformation induced by the active and preventing safety systems evolution moving from being only activated by on-board sensors to a larger spectrum of sensors including both vehicle, other vehicles (Vehicles to Vehicles – V2V) and infrastructure

(Vehicles to Infrastructure – V2I). This technological evolution is creating so-called *cooperative ADAS* perspective [16] where preventive capabilities of such systems is allowed by the connection of the infrastructure. In terms of HMI, it is evident that vehicles are not necessary and exclusively oriented towards a dimension characterized by warning-based interfaces. Although this mechanism tends to persist, as well as to be necessary, it is also evident that within a system characterized by a high level of cooperation, the warning-based system might be easily replaced by a *recommending-based mechanism*. In other words, if vehicles are able to mutually recognize each other, as well as to cooperate for exchanging information and data, the system for supporting the driver will be aimed at sharing behavioural choice among the cars, rather than imposing and reporting imminent dangers. D3COS EU project (www.d3cos.eu) – among its results – have firstly proposed such promising concept in HMI for preventive accident systems [29]. This new dimension represents a real shift of paradigm going towards an increasing level of automation.

The third phase is characterized by the integration between the cooperative and the warning-based dimensions from one side, and the increased level of automation in cars (according to SAE Standard J0316) from the other. In this situation, expected HMIs will raise even more complex issues. Firstly, if on one hand it is true that automation will set the driver free from the necessity of constantly driving the vehicle, on the other hand, the driver is obliged to continuously monitor the correct functioning of the whole system. In a pioneering work, [1] expressed the idea of a sort of *irony* hiding behind the concept of automation. In fact, if theoretically speaking, the purpose of automation is to exclude the user from the driving tasks, in practices autonomous systems tends to encourage even more the participation of the driver, who must continuously monitor the correct functioning of the mechanism. The more the vehicle is autonomous, the more the driver is responsible for the only monitoring and the design issues for HMI designers is how to provide the best monitoring and to re-allocate the control to the drivers in the most effective and quicker way.

10.4 HMI Concepts Design

The three HMI concepts developed within the DESERVE project included the information normally displayed in the dashboard (i.e. speedometer, odometer, fuel level and water temperature information, diagnostic telltales, etc.), ADAS information support (i.e. lane change assistance system, nigh view, parking aid, adaptive cruise control, etc. as well as drowsy driver alert system) and navigation information.

Moreover a particular attention was dedicated to the design layout of the drowsy driver alert system. Drowsiness detection can be used to give a direct warning to the driver (explicit drowsiness) or as an input for an HMI reconfiguration strategy (implicit drowsiness). These two different strategies for drowsiness management were applied to all the three HMI concepts, obtaining hence 6 concepts to test. For the explicit drowsiness a warning is delivered to the driver with an icon and a message. For the implicit drowsiness ADAS sensitivity is set to the highest level. Once the driver takes a break, the ADAS configuration s/he set before is restored.

The user interface deploys 17 functions: 13 of them are ADAS, 2 are Safety Assistance Systems, and 2 are IVIS (In-Vehicle Information System), as listed in the following:

1. Lane change assistance system (ADAS);
2. Night vision system with pedestrian detection (ADAS);
3. Rear view camera system (Safety Assistance);
4. Surround view (Safety Assistance);
5. Lane departure warning (ADAS);
6. Pedestrian safety system (ADAS);
7. Collision warning system (ADAS);
8. Emergency braking ahead (ADAS);
9. Rear approaching vehicle (ADAS);
10. Adaptive high beam assist (ADAS);
11. Adaptive cruise control (ADAS);
12. Curve warning system (ADAS);
13. Intelligent park assist (ADAS);
14. Traffic sign recognition (ADAS);
15. Driver impairment warning system (ADAS);
16. Navi/Map info (IVIS);
17. Setting menu (IVIS).

10.4.1 Concept 1: Holistic HMI

In the Holistic HMI concept all the HMI elements (I/O) are centralized in front of the driver. The Instrument Panel Cluster (IPC) is the main visual output channel, while the steering wheel (SW) is the main input channel.

The HMI elements are listed as follows: i) IPC display 12”; ii) SW commands; iii) Left stalk commands; iv) Buttons; v) Knobs.

The instrument panel cluster was divided in three areas. In the central area the following information are delivered: lane change assistance system, night vision system with pedestrian detection, rear view camera system, surround view and setting menu.

The left area is mainly dedicated to the hazard warnings: lane departure warning, pedestrian safety system, collision warning system, emergency braking ahead, rear approaching vehicle, adaptive high beam assist, adaptive cruise control, and curve warning system are displayed.

In the right area the following information are delivered: intelligent park assist, traffic sign recognition, driver impairment warning system and navigation.

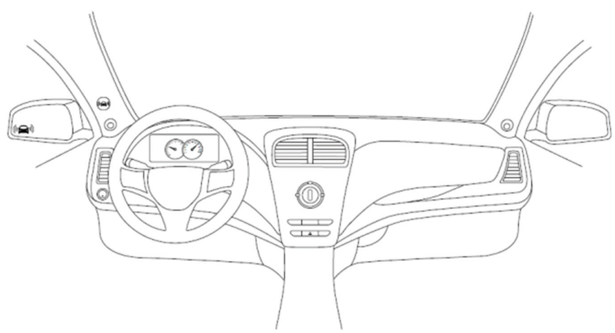

Figure 10.2 Holistic HMI concept, that shows: IPC display 12”; SW commands; left stalk commands; buttons; knobs.

Figure 10.3 Holistic HMI layout.

Figure 10.4 Holistic HMI layout with the user menu in the central area.

Figure 10.5 Holistic HMI layout with the lane change assist in the central area.

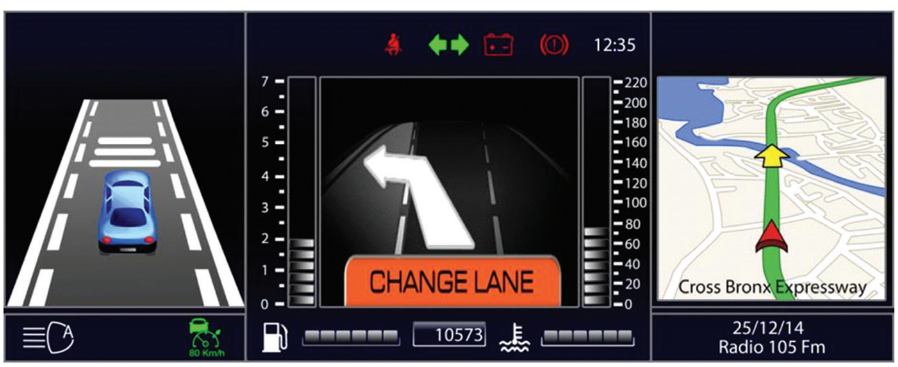

Figure 10.6 Holistic HMI layout with the rear view camera in the central area.

Figure 10.7 Holistic HMI layout with the night vision system in the central area.

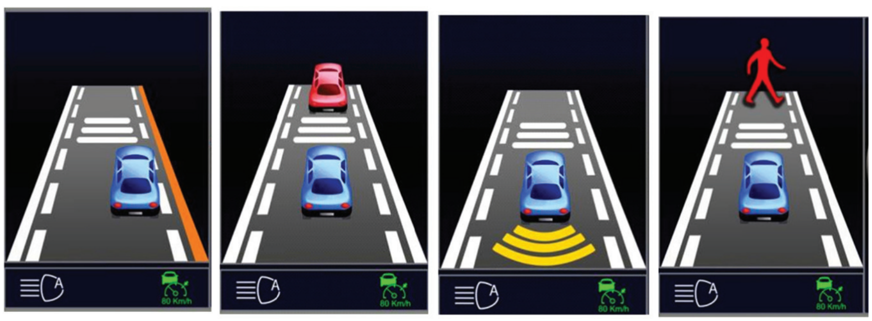

Figure 10.8 (A-B-C-D) Holistic HMI left area with: lane departure warning, collision warning, Rear approaching vehicle system, pedestrian safety system.

10.4.2 Concept 2: Immersive HMI

The second concept is totally different from the previous one. While the Holistic HMI concept centralizes all the info and the interaction with the driver in front of him/her, the Immersive HMI concept distributes the interaction along the dashboard and the windscreen.

The HMI elements of concept 2 are listed as follows: i) 3,5" IPC display; ii) Touch Display 8,5" in the dashboard; iii) Head-up display for the windscreen; iv) SW commands; v) Left stalk commands; vi) Buttons; vii) Knobs.

In the concept 2 the area dedicated to the hazard warnings was moved in the middle of the instrument panel cluster, while the navigation, the rear view camera, the night vision system, radio/multimedia, phone and menu applications were moved to the dashboard display. The head-up display delivers traffic sign recognition and lane change assist information on the windscreen.

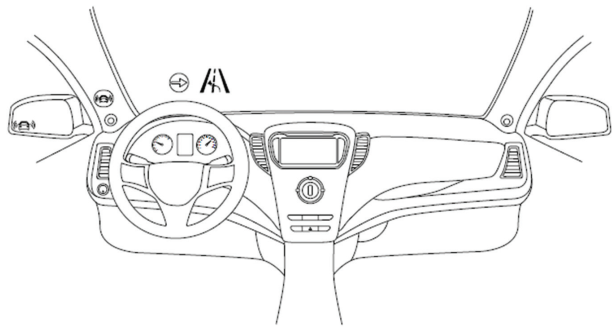

Figure 10.9 Immersive HMI concept shows: 3,5" IPC display; touch display 8,5" in the dashboard; head-up display for the windscreen; SW commands; left stalk commands; buttons; knobs.

10.4.3 Concept 3: Smart HMI

The third concept replaces the dashboard display with a nomadic device (ND – i.e. smartphone/tablet). The HMI can reconfigure itself according to ND size.

The IPC display has the same structure of that one of concept 2. The difference is that in the Smart HMI concept the 3,5" display of concept 2 was integrated by adding, for example, a 7" tablet (as in Figure 10.7) seamlessly connected with the car system. Drivers just connect the phone with a cable and immediately s/he gains access to ND applications using dashboard/steering-wheel buttons. The ND can provide also the access to further automotive applications. Driver can define what kind of information has to be shown in the ND: the ND is able to manage the infotainment functions and some ADAS applications.

Figure 10.10 Immersive HMI concept: instrument panel cluster display.

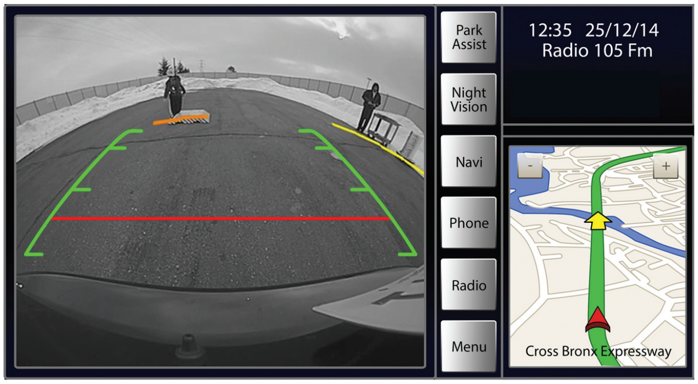

Figure 10.11 Immersive HMI concept: dashboard display.

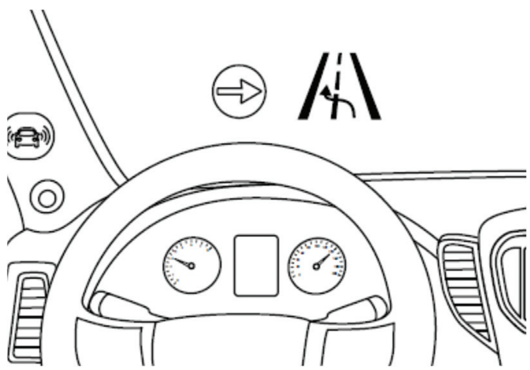

Figure 10.12 Immersive HMI concept: head-up display details.

The HMI elements of concept 3 are listed as follows: i) Display 3,5" in the IPC: ii) Touch Display of the nomadic device set into the dashboard; iii) SW commands; iv) Left stalk commands; v) Buttons; vi) Knobs.

10.5 Preliminary Testing by Focus Group

As Morgan described, "in essence, focus groups are special occasions devoted to gathering data on specific topics [21]". Using a focus group leads to evaluate preliminary concepts and in this case it is a useful technique to evaluate the proposals explained before [28], [35] having in mind that focus group is a technique deeply used in automotive field to evaluate user experience regarding HMI concepts [2, 9–12, 17].

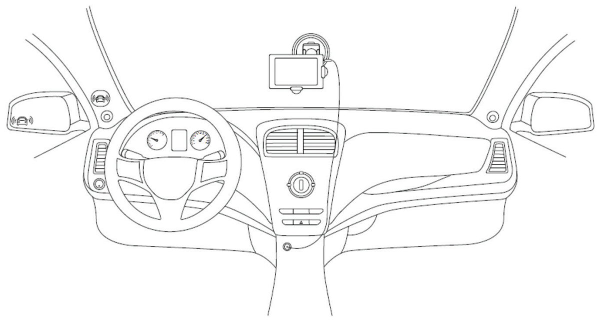

Figure 10.13 Smart HMI concept.

Figure 10.14 Smart HMI concept: Nomadic device with night vision system.

10.5.1 Participants

Sample is composed by 7 participants with a range of age between 25 and 39 years old (M = 31.71; SD = 4.06). Around 30% drive between 10000–15000 km/year and around 45% more than 20000 km/year. All drivers run at least once a day during the last year. 2 drivers run than 10% of their total driven by city, other 2 drive between 20–25%, and 3 run at least 40% or more of their driving in city. Moreover, around 40% drive usually on dual carriage way, and 30% run on highway and in similar percentage, 30%, drive on main roads.

10.5.2 Results

Participants discussed and exchanged points of views about HMI. They gave scores about degree of utility, easy to use, easy to learn, visual clarity, if the concepts were intuitive, degree of accessibility, and degree of driver annoyance and finally they provide a global value.

The HMI concept 1 (with explicit drowsiness) was considered as very useful, enough easy to use, with the most visual clarity and degree of accessibility among all the options presented. Having information located in same area is positive to avoid distraction and the three delimited areas for presenting information are pleasant. In general, alternative to concept 1 (with implicit drowsiness) is less appreciated than the original one. Scores are lowest than previous concept and the absence of drowsiness icon is missing by focus group participants.

Regarding HMI concept 2 (with explicit drowsiness), most of the participants appreciated to have information on HUD, moreover to have primary information in a different place from secondary one is a positive attribute. Besides, this concept seems to be a bit more easy to use and to learn and more intuitive. Concept 2 bis (with implicit drowsiness) is measured as intuitive and have visual clarity. Once more, HUD information is well appreciated by focus group participants. Anyway, it should be necessary to take into account that drivers are not being confident to manage drowsiness without a detailed icon.

Concept 3 (with explicit drowsiness) is not really appreciated from an aesthetically point of view. It is enough useful, easy to use and learn and enough intuitive. Focus group participants liked the possibility to place tablet where they prefer although it could mean less frontal vision. Last concept (n. 3 with implicit drowsiness) showed participants the least acceptable one. Although it will be positive to place the table according the wishes of drivers the general impression of having information in this way is not positive, even if it is having in mind that there is not drowsiness icon.

10.5.3 List of the Winning Features and Redesign Recommendations

As it can be observed in the radar chart which summarizes the HMI evaluation for the six concepts, concept 3 and its alternative, concept 3 bis (with implicit drowsiness) were the concept less valued. This concept “3 bis” is the concept which is considered more annoyed. Concept 2 had the highest average score for the global evaluation but concept 1 is closed to concept which adds information on a HUD and touch dashboard. Concept 1 stands out by its accessibility, utility and visual clarity and concept 2 is highlighted by its feature to be easy to use and it is a bit more intuitive.

During the session participants pointed several issues that should be taking into account:

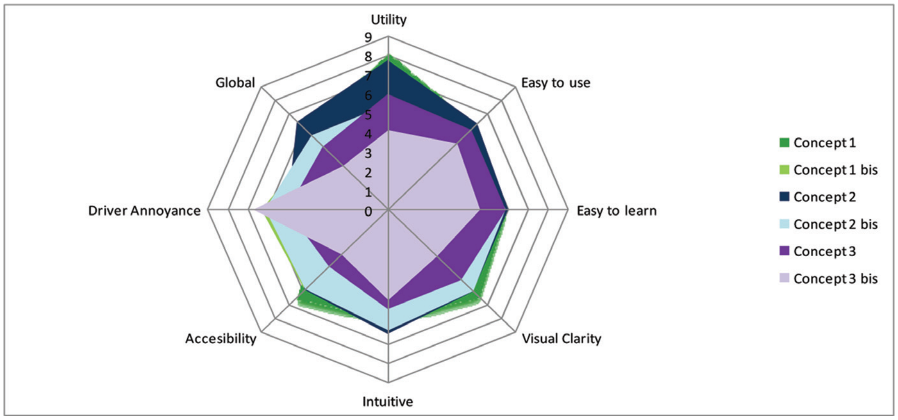

Figure 10.15 Radar chart summarizing HMI evaluation for the 6 HMI concepts. Bis concepts are concept 1, 2, 3 with implicit drowsiness.

- Summarizing the best option should have drowsiness icon.
- Option concept 1 and concept 2 are the best.
- The possibility to have HUD information is really appreciated.
- Participants suggested having in HUD the following information: traffic signals, gap for ACC, navigator system (with arrows and distances).
- For traffic signal information, it is very important to them to maintain this information available because sometimes you forgot this information (e.g. when you are running by a road and you forgot which was the speed limit).
- Information should be very clear and concise.
- It should be a great idea to have the possibility to select where you want to have the navigation system.

10.6 Users Test at Driving Simulator

As a final step for the definition of the overall HMI concept the two winning option from the focus group, namely concept 1 and concept 2 with the explicit drowsiness icon, were tested with users on a driving simulator in order to identify the final DESERVE HMI concept configuration. Each user was interviewed alone by a usability expert gathering comments and suggestions about the different ADAS function disposition and visualization.

Among the 13 ADAS functions developed for the DESERVE project, it was decided to test only 4 ADAS functions that were considered representative of the main HMI concept logic. In particular the following ADAS functions were widely tested with users:

1. Forward collision warning – with acoustic signal type 1.
2. Rear view camera system.
3. Lane change assistance system – with acoustic signal type 1.
4. Drowsiness icon – with acoustic signal type 2.

10.6.1 Participants

Sample is composed by 30 participants (20 Male and 10 female) with a range of age between 23 and 62 years old (M = 32.17; SD = 7.15). The majority of participants achieved a Master's degree.

The 30% of participants drive more than 20.000 km/year and the remaining between 10000 and 15000 km/year (M km/year = 15600; SD = 6931.18).

10.6.2 Procedure

After a brief explanation of test objective and some questions on personal data, user where asked to seat on the driving simulator and imagine to be inside their car, at the driving place with a dashboard of your car in front where some information about the car, its functioning and so on are displayed. Before assessing the solutions users where asked to practice a little with the driving simulator and to count the stars that appear on the road.

In particular user where asked to evaluate on a 7 point scale:

- The suitability of the HMI concept tested;
- The comprehensibility of the information displayed;
- The number of the information displayed;
- The pleasantness from a graphical point of view of the HMI concept tested;

10.6.3 Results

From the analysis of the different part of HMI concept test, concept 1 seems to be the preferred one even if the difference with the percentage of users that prefer concept 2 is not statistically significant. Despite this result the 60% of users would like to have the warning information in the central part of the display instead of in the lateral part. The functions representation seems quite clear for all users, only the adaptive light control and the adaptive cruise control icon should be re-designed. Considering the result of the task that

Figure 10.16 Proposed change to create the final DESERVE HMI concept.

Figure 10.17 Final DESERVE HMI concept: warning area.

Figure 10.18 Final DESERVE HMI concept: rear view camera.

Figure 10.19 Final DESERVE HMI concept: navigation.

asked users to build their own solution, almost all distributed all functions in the same central display.

Thanks to users' feedbacks, the final DESERVE HMI concept has a single display with the warning functions in the central area and the gauges in the lateral part of the display.

10.7 Conclusions

Most cars today contain heterogeneous ADAS that support safe and clean driving. Because the pattern of factors in the automotive domain is constantly changing (new technologies and devices on board, new infrastructure, new mobility concepts, new trends in pollution prevention), the accident characteristics of the transport domain are also changing. As a consequence, also the research in that domain changed perspective, starting to investigate the human factor in order to improve safety and to prevent accidents. Even if it is not feasible to exactly predict the next accident, it is possible to anticipate some decisive characteristics of future accidents, as driver's misbehaviour. All these features concur in defining a new concept of ADAS system as a support and sometimes as a partner for drivers during task accomplishment and no more as a mere substitute.

Since nowadays more and more ADAS function are going to be implemented in current vehicles, the need for a unique Human Machine Interface is becoming an issue that reflects the increasing complexity of the entire system, whereby the driver has to deal with different devices and different interaction strategies. The aim of this work was in fact to identify the most suitable HMI concepts that allow an easy integration of different ADAS function in order to guarantee the safety of the introduction of any new element.

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