On the way to automated vehicles: the evolution of user interfaces
Even today the ever larger vehicle displays and tachometers or driver displays that are more or less freely configurable indicate where we are heading: Display of vehicle operating conditions as well as all aspects of infotainment are placing sharply increasing demands on HMI intelligence and flexibility. The HMI is becoming a "Smart User Interface".

Illustration 1: Freely programmable instrument clusters enable the situational use of the display area behind the steering wheel.

With the gradual introduction of automated driving functions, the functions of the HMI will continue to change on the basis of degree of automation. It is precisely during this transition phase, characterized by partially and fully automated driving, that traditional displays and functions must continue to operate, while new tasks occur. The HMI must focus on providing information on aspects of the driving process and the precise extent to which they are controlled by the supporting functions. The goal is to keep the driver’s level of attention as high as possible, avoid any distractions and at the same time to convey all relevant information. More than ever, the HMI is becoming a safety-critical vehicle component. As a result, operating systems and display systems are transitioning into components where standards such as ISO-26262 are relevant to their functional safety. It describes methods and models that need to be observed in the course of development and production of safety-relevant vehicle systems.
Partially automated driving requires trust

The expanding scope of performance from partially automated functions further intensifies requirements. The operator must, on the one hand, have a high degree of confidence in his vehicle and in particular the HMI. Only then will people be willing to transfer the entire control of the vehicle to the various systems. On the other hand, the driver of the vehicle must continuously monitor the state of the system and be able at any time to take over the control of the vehicle again. And finally, the vehicle systems have to be able to draw the driver’s attention to exactly where it is needed.

In order to achieve this, developers should be working on other features in addition to cockpit displays. These include head-up displays (HUD), interior lighting, audio information or even tactile signals. To do this, the traditional form of head-up displays can be extended to cover augmented reality. This kind of an "AR HUD" that is developed jointly by Elektrobit and Continental, visualizes for instance the lateral guidance planned by the system or marks the vehicle in front for which adaptive proximity control is activated. An advantage of this approach is that the driver can get information on complex driving situations, without being distracted by having to look away from the road.

Illustration 2: Visualization of the view through a windshield: Augmented reality elements extend the head-up display (AR HUD).

Intelligent HMI components must also decide which information has the highest priority at what time and must be prepared to hide less important information in complex or even critical driving situations.

Moreover, at this stage of development the HMI has to be able to detect the driver’s attention. Such features are available in rudimentary form these days - for example, using steering wheel sensors, software is able to analyze the degree of the driver’s concentration and if necessary, suggest a coffee break. Extensions, ranging up to eye-tracking or interior cameras, are conceivable through the use of additional sensors. However, even less invasive solutions are possible and these include an analysis of the temporal and content-based sequence of operations performed by the software.

Providers of HMI components and the associated software solutions can support developers with specialized tools, that can be used to model HMI functions.
Highly automated driving requires efficient attention control

In certain situations, the requirements will change once again if the support systems operate in a highly automated mode. The driver may dispense with monitoring the systems over a given span of time provided that this is permitted by the statutory provisions. As has already been demonstrated in concept vehicles, this could be clearly conveyed to the driver by the steering wheel being mechanically retracted. The control of these functions is also based on a close interaction of vehicle systems and HMI.

The operator must again take control within a time buffer of a few seconds, if this is what the driving situation or the system status demands. In this context maintaining and monitoring the driver’s attention is even more important. The targeted use of elements from the field of entertainment is a concept used for maintaining the driver’s concentration. We’re also talking about “gamification” here: the use of concepts from computer games to control attention and to convey information. This is also not restricted to the central display in the cockpit, but could also be used in a Augmented Reality HUD. In any case, this calls for a high degree of interaction between the assistance systems and the HMI.

If the system needs to ask the driver to take control again, then conversely it may also become necessary to revoke access to entertainment content, messaging and the like. The moment the systems identify that the driving situation is potentially difficult for the driver, it becomes important for the driver to get his concentration back to driving quickly and effectively. There is more time available for this in predictable situations, such as getting off the highway, or areas that are covered by high-resolution map data. However, this period can also be very short in unexpected situations such as passage of wild animals, sudden accidents or weather events. To communicate this clearly to the driver it is practical to have a countdown that displays the time remaining for control to be resumed. Of course, the system must also include a strategy to handle cases where the driver does not respond to such a request. This is usually a controlled emergency stop.

Multi-modal concepts are promising particularly if the driver’s attention needs to be quickly diverted back to the traffic situation and the driving task. In its "Driver Focus" concept vehicle, Continental concentrates on illuminated bands in the doors and in the upper side of the cockpit to direct the driver’s attention quickly in the desired direction. Even haptic or tactile elements such as vibration elements in the seat or tension of the seat-belt pretensioner are priority concepts in this context.
Will the future see vehicles totally without steering wheels?

In reality, the road maps for vehicle autonomy do not anticipate fully automated driving before the year 2025. Despite this, it is mainly the non-industry players such as Google that are even today keeping track of this particularly radical approach.

Such fully-automatic vehicles have no steering wheel at all and interaction with the driver is not provided for. However, at least on some occasions there will be longer periods for vehicle occupants to hand over the entire control of the vehicle. This also has enormous consequences for the HMI. Its focus then shifts sharply to the aspects of entertainment and comfort; then other activities such as work or relaxation that gain priority during the journey must be optimally supported. This could, for instance, be video projections on the inside of the vehicle or large displays on the doors of the vehicle. At the same time, other controls for comfort functions such as seat adjustment and seat temperature including luxury aspects such as a massage function or adjusting interior temperature must be available and these functions must be integrated in the overall concept of the vehicle. Various tools are required if all the challenges described above are to be met. These include a module of different HMI elements, intelligent software and flexible tools for development and modeling of the corresponding solutions.

Moreover, for automobile manufacturers to stand out in a competitive market environment and to further promote their own brand image, they also need to retain control of these operating concepts.
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Elektrobit Automotive GmbH
Am Wolfsmantel 46
91058 Erlangen, Germany
Phone: +49 9131 7701 0
Fax: +49 9131 7701 6333
sales@elektrobit.com
elektrobit.com