Tips & Technology

For Bosch business partners

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Electrics / Electronics

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Automated driving – The future of mobility

High-performance driver assistance systems already help to make motoring safer and more relaxing. In future such systems will be capable of mastering ever more complex traffic situations to provide drivers with assistance – or even take autonomous action. Each innovation represents a further step towards accident-free automated driving.

Global developments

Megatrends are a real driving force in a society. They reflect processes of change taking place over a period of decades. Megatrends not only give rise to certain social, political and economic developments, they are also capable of completely transforming societies. Listed below are some examples of particular relevance to automated driving.

- Urbanization:
  More and more people are living in towns and cities, associated with an increase in the volume of traffic and environmental pollution. New vehicle and mobility concepts are called for.

- Demographic change:
  The proportion of older people is growing. Today's senior citizens are more mobile and active, however they also feel a greater need for safety.

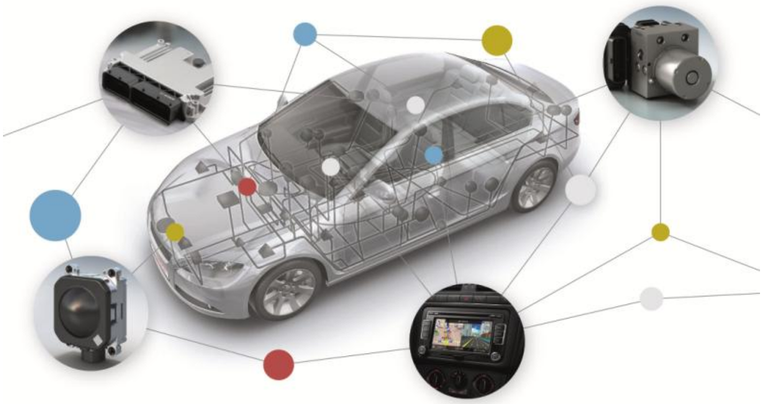
- Networked society:
  Thanks to mobile phones and computers everyone can now be online wherever they want. The "Internet of things and services" means that not just people, but also devices are able to communicate with one another.

- Traffic safety:
  Traffic safety is becoming an ever more important topic of discussion for both the public and lawmakers. The United Nations (UN) have declared the period from 2011 to 2020 to be the "Decade of Action for Road Safety", with the aim of halving the number of worldwide road deaths by the year 2020.

- Clean technologies: Climate change, the increasing volume of traffic around the globe and the shortage of fossil fuel resources all demand new energy and mobility concepts.

Degrees of automation

Modern driver assistance systems represent a stepping stone towards the automated driving of the future. The German Federal Highway Research Institute distinguishes between various degrees of automation based on the extent to which drivers have to monitor the traffic situation and are responsible for vehicle control.



The higher the level of automation, the less the driver has to do – creating greater freedom for productive activities, communication and entertainment whilst traveling. The first partly automated functions such as the traffic jam assistant will be available on the market within the next two years, to be followed by functions with a higher degree of automation. Fully automated functions will be a reality by the end of the decade.

Manual
Drivers are responsible for longitudinal control (acceleration/deceleration) and lateral control (steering) at all times.

Assisted
Drivers are always responsible for either longitudinal or lateral control, whilst the system implements the other task within certain limits. Drivers have to constantly monitor the system and be ready to take full control of the vehicle at any time.
Examples: Adaptive cruise control, lane keeping assist, parking assist

Partially automated
The system assumes both longitudinal and lateral control (for a certain period of time or in specific situations). Drivers have to constantly monitor the system and be ready to take full control of the vehicle at any time.
Examples: Automatic parking assist, integrated cruise assist, traffic jam assistant

Highly automated
The system assumes both longitudinal and lateral control for a certain period of time in certain situations. Drivers no longer have to monitor the system whilst it is in action, but can hand over complete control to the system, at least for a certain time. If necessary and with a sufficient reaction time, drivers are prompted to take over vehicle control. All the performance limits are recognized by the system, but it is not capable of bringing about the minimal risk condition from every initial state.
Example: Traffic jam pilot

Fully automated
The system assumes full longitudinal and lateral control for a defined application. The driver does not have to monitor the system whilst it is in action. Prior to the end of the application and with a sufficient reaction time, the system prompts the driver to take over control. If the driver does not do so, the system re-establishes the minimal risk condition. All the performance limits are recognized by the system. It is capable of re-establishing the minimal risk condition in all situations.
Examples: Highway pilot, exit-to-exit

Legal framework

In many countries, the law demands
- That a driver must be responsible for any vehicle in motion
- That the driver must constantly be in a position to maintain control of the vehicle
- That drivers must desist from all activities other than controlling the vehicle

Informative driver assistance systems comply with these stipulations, as drivers decide for themselves whether and how to react to system information. This applies for example to lane departure warning, Park Pilot or blind spot assist systems. Intervening driver assistance systems also conform to the applicable regulations, as they either provide drivers with assistance for a particular task (e.g. ABS, emergency brake assist) or can be overridden at any time by the driver (e.g. lane keeping assist).

At present, partial automation as an advanced form of driver assistance system is subject to the same provisions as driver assistance systems. With partially automated functions, the driver's attention is constantly concentrated on the traffic situation, the driver monitors the systems and always has the option of taking control of the vehicle.

Highly and fully automated vehicles on the other hand give rise to new legal questions, as they do not provide the option of vehicle control by the driver and do not require the driver to concentrate on the traffic situation. This is not reconcilable with the legal situation at present, as the human driver would be contravening his obligations if he were to rely entirely on the system. If a system were to permit hands-free vehicle control, behavioral analysis would be necessary to clarify whether the system would impair the driver's ability to exercise constant alertness as defined by the German Road Traffic Act.

The situation is different with regard to systems which assume control for a short period to bring the vehicle safely to a halt in an emergency if the driver suddenly becomes unfit to drive. Such systems are not subject to the above-mentioned restrictions in the same way – even if they exhibit a higher degree of automation. This applies to automatic full braking or emergency stop assist for instance.

The 1968 Vienna Convention forms the basis for road traffic law in Central and Eastern Europe, Brazil and certain other countries. Article 8 of the agreement stipulates that a driver must be responsible for any vehicle in motion, that the driver must constantly be in a position to maintain control of the vehicle and that drivers must desist from all activities other than controlling the vehicle. Article 13 of the Convention requires all drivers to be in control of their vehicles under all circumstances to be able to satisfy their obligations to exercise due care and to constantly be in a position to maneuver the vehicle as necessary.

The introduction of automated driving will require changes to the legal framework. Some states in the USA have already issued regulations governing the use of self-driving vehicles to promote their development.

Are driver assistance systems in conformity with the Vienna Convention?

Driver assistance systems can be roughly divided into the following categories:

- Informative driver assistance systems, e.g. forward collision warning, lane departure warning, blind spot assist
- Intervening driver assistance systems, e.g. ABS, brake assist, ESP®, automatic emergency braking, lane keeping assist

All informative driver assistance systems comply with the Vienna Convention, as drivers decide for themselves when and how to react to system information.

A further distinction is required with regard to intervening driver assistance systems:

- Intervention initiated by the driver: The driver assistance system provides assistance for a task/activity initiated and intended by the driver, e.g. ABS, brake assist and emergency brake assist provide support on braking.
- Intervention by the driver assistance system which can be overridden by the driver: The driver remains in control of the vehicle, as the assistance system can be overridden at any time, e.g. lane keeping assist.
- Intervention by the driver assistance system which cannot be overridden by the driver, e.g. ESP® and automatic emergency braking. The system is only activated if the driver is no longer in a position to avoid an accident and the consequences of the inevitable collision can only be mitigated by emergency braking. In such cases it is assumed that the driver has already lost control of the vehicle. These systems are thus considered to be in conformity with the Vienna Convention.

What are the most important aspects with regard to liability and insurance?

Automated driving will enhance traffic safety in general. Around 90 percent of all accidents are caused by human error. Automated vehicles can avoid risk situations far better than a human driver and adhere reliably to the rules of the road without becoming tired, bored or emotional. Accidents will however still occur in future. At present there is no legal framework for dealing with this. Governments and administrative bodies in many parts of the world are currently exploring the possibilities for regulating such situations.

The technology

Driver assistance systems form the basis for the automated driving of the future. They have been in series production for many years now and are becoming increasingly popular (e.g. ABS, ASR, ESP®, ACC).
Adaptive cruise control (ACC) systems are already capable of recognizing vehicles on the road ahead and adapting both distance and speed accordingly. With the addition of just a few more components this forms the technical basis for automated vehicle control, involving an ESP® link, a video camera for lane detection and electromechanical steering.
High-performance software calculates the appropriate commands for safe, relaxed driving. Automatic lane changing is the next functional step. This requires additional surround sensors at the rear capable of detecting rapidly approaching vehicles and a so-called dynamic navigation map.
Automated vehicles not only have to observe all the rules of the road – they require the extra capabilities which humans also need when driving. They must be able to "see" their surroundings, take independent decisions and be capable of autonomous acceleration, braking and steering.

The essential key technologies are:

Sensors for the surroundings and the driver

A technology crucial to automated driving is precise and reliable sensing of the surroundings. As the vehicle is intended to travel independently in real traffic, it must be capable of detecting all the relevant road users in the entire surrounding area (360 degrees) and reliably assigning these to the correct lanes. To achieve this, each part of the vehicle is monitored by several sensors employing various measurement principles. The use of redundant sensors enhances the reliability and dependability of the information.

The surround sensors must provide a constantly available, absolutely reliable, true 3D image of the vehicle surroundings. Most of the surround sensors required for this purpose are already in series production. Alongside ESP® and electromechanical steering, these sensors are also available from Bosch. The conventional combination of radar, video and ultrasonics is however not in a position to cover all applications, which is why Bosch are working on new sensor technologies to satisfy the high standards of surrounding area sensing required.

Data is gathered from the individual sensors and processed to form a complete surrounding area model containing all the static and dynamic objects. Completely new hardware and software technologies and algorithms are employed for these calculations. The objects detected are then precisely assigned to the various lanes – which involves the vehicle localizing itself on digital maps. This enables the vehicle to interpret the situation, recognize drivable areas and derive a driving strategy.

Highly and fully automated functions not only have to keep an eye on the surroundings – but also on the driver, as the driver no longer has to monitor the system with these functions. He can delegate complete control to the system, at least for a certain time or in a defined situation. Afterwards the driver is prompted to re-assume control – and the vehicle must be capable of recognizing whether he is in a position to do so.

At present, handover of vehicle control from the system to the driver still represents a challenge to development engineers. How long can this be allowed to take? What happens if the driver does not take over control? One possible scenario: If, on approaching a defined motorway exit for example, the driver does not intervene, the automated vehicle automatically stops on the hard shoulder and sends out an emergency call.

Position determination

Real time, high-precision dynamic position determination is an essential aspect of automated driving. It has a crucial role to play in ensuring exact positioning of the vehicle in the lane to prevent obstruction of other road users.

Position determination must be constantly available, dependable and accurate. A sensor alone is not capable of satisfying all these demands, which is why use is made of a combination of data from satellite navigation, landmarks (lane markings and roadside structures) and a high-precision digital map. Alongside all the lanes and roadside structures, this dynamic map also contains information on bends. A wireless link keeps the map constantly informed about current speed restrictions, changes to the road network and even temporary road works.

Automated vehicles have to calculate a preview of the vehicle surroundings well beyond the scope of the short-range capabilities of radar or video sensors. This preview is referred to as the electronic horizon. The necessary calculations are made on the basis of exact real time position determination by way of the global navigation satellite system (GNSS). Using the information obtained and following assimilation with the current vehicle parameters, the system can plan a driving strategy such as a lane change maneuver.

Driving strategy

The driving strategy determines how an automated vehicle is to behave in road traffic and calculates the values required for vehicle control. The vehicle must also be capable of assuming tasks which are a challenge even to humans.

It has to independently decide where it is going and when to accelerate, brake or take steering action – and all this based on rapidly changing information. In other words, the system must take its entire surroundings into account when calculating a route and guiding the car quickly, safely and accurately.

The question of safety also comes into play if a vehicle is to assume tasks normally performed by humans. The risk of mechanical failure can be reduced to a minimum but not completely eliminated. In the event of system failure it must therefore be possible to bring about a safe condition even without the intervention of the driver.

The next steps

The technical developments of the past few years are gradually progressing towards fully automatic driving. Higher driving speeds on motorways will become possible with increasing degrees of automation for example. Such systems will only be accepted by motorists if they offer convincing functions and are easy to operate. Intuitive understanding of both the action of the functions and their limitations is an essential prerequisite.

The trend towards automated driving presents new technical challenges with regard to surround sensors, actuators and the electrical/electronic architecture in a vehicle. It will also be necessary to standardize the communication protocols for the exchange of data between vehicles.
Urban traffic remains the greatest challenge in developing automated functions, as this involves making allowance for all sorts of road users moving in all directions. In addition there is a need for concepts to guarantee that the system always functions reliably and with due consideration to every situation encountered. For general operation it is also necessary to have a critical mass of vehicles (roughly 10 percent) which are able to communicate with one another.

Leaving aside the technical challenges, existing laws will have to be adapted or new laws created in order to pave the way for automated driving.