compact²
The way we will drive tomorrow
Entering the future

All over the world, mobility is on the threshold of a revolution: Numerous little technical helpers are already making our everyday lives easier, but automated and connected driving will soon open up a whole new range of possibilities. As the digital era increasingly reaches deeper into driving, travelling and the transport of goods, we will see significant changes in these fields. Cars will communicate with each other and warn each other of dangers. The necessary data will be provided either by the vehicles themselves or by smart information systems along transport arteries. All this will help us to better manage difficult driving situations in the future and make our journeys even safer. Germany once invented the automobile. Now we are developing vehicles and strategies that will shape digital transport in the decades ahead. This is what makes Germany a pioneer in the field of automated and connected driving. The Federal Ministry of Transport and Digital Infrastructure (BMVI) is creating the optimum conditions by adapting and future-proofing the legal framework. It is also promoting standards for efficient and safe technology at both the national and international levels. The BMVI is supporting the roll-out of digital infrastructure with targeted investments as well as research projects that will provide us with the best expertise to accompany us on our way to the future.
THE CAR OF THE FUTURE

Open up new spaces

Car enthusiasts around the world are excited to see how mobility will change in the years ahead. Industry is also spellbound by the possibilities awaiting us. And it should be, because increasing digitalization and connectivity will have an enormous impact on the way we move.

In a few years, we will be able to surf the Internet while our vehicle finds its way to the desired destination autonomously, or to watch the latest news, enjoy our favourite movies and do our online shopping on our way home. The car will assume an entirely new role. After our homes and our workplaces, it will become the “Third Place”.

New requirements

Germany has one of the most efficient transport networks in the world. Our motorway network alone is almost 13,000 kilometres long. However, for automated and connected driving to become reality in the future, digital infrastructure must be provided along thousands of kilometres of roads. Only then will we be able to manage the data flows required for connected driving. For our vehicles to be able to communicate in real time, the Federal Ministry of Transport and Digital Infrastructure is not only promoting the deployment of a high-performance broadband network but also the cooperation between the automotive and IT sectors. By using mobility and spatial data intelligently, modern information systems could soon warn us of road works ahead and inform us about free parking spaces in our vicinity. In this way, we would lose less time searching for a parking spot while at the same time preserving our environment and minimizing the stress imposed by traffic on local residents. Last but not least, we would also increase road safety: Cars will be able to adapt their speed to the density of traffic – controlled by intelligent traffic management.
1. DRIVING WITHOUT ASSISTANCE SYSTEMS
For decades, people were driving without technical aids. In the mid-1990s, to improve safety, vehicles were gradually equipped with anti-lock braking systems (ABS) or Electronic Skid Protection (ESP).

2. ASSISTED DRIVING
At the end of the 1990s, the first vehicles with allround environment-sensing systems went into mass production. In simple driving situations, they are already taking over specific driving tasks. On the motorway, for instance, they can automatically maintain a safe distance from the vehicle in front. However, the driver must constantly monitor the system.

3. PARTIAL AUTOMATION
This is where we currently are. The tasks the car can assume are becoming more and more complex – even if the driver still has to continuously monitor the system.

4. CONDITIONAL AUTOMATION
Cars will autonomously assume driving tasks such as braking, steering, changing lanes or overtaking. If a situation can no longer be managed automatically, the driver will be prompted to take over. Such systems will already be ready for mass production in 2018.

5. HIGH AUTOMATION
In this stage, the system will assume full control over many driving tasks and will no longer have to be monitored. If the automated mode has to be aborted, the system will prompt the driver to take over. Should there be no reaction by the driver, the system will, for instance, bring the vehicle to a full stop on the verge.

6. FULL AUTOMATION
Driverless cars will not be operating on our roads before 2025. People will become passengers. It will no longer be necessary for a human to intervene in the driving process.
My car talks with me

The talking car is no longer science fiction. Lane keeping assistants warn us when we cross the edge of the carriageway marking, sensors monitor our environment and warn us of collisions. Even traffic signs can be detected automatically. In short: Millions of drivers are already enjoying the benefits of numerous little helpers and are travelling more safely and more comfortably.

In the years ahead, the car will become either a helping passenger or a friendly chauffeur. New driving functions will lead to more safety, save fuel and are less harmful to the environment by searching for the optimum route and adapting the driving style to the routing. Together with other sensors and information from traffic management centres, we will be immediately informed if something on our route is wrong.
Safer together

The vehicle of the future will be connected to other vehicles and the digital infrastructure. They will exchange information. Data will be transferred via mobile telephony or WiFi, for which a special spectrum has been reserved. If a vehicle approaches the end of a tailback, the system will transfer the relevant information in a split second. In this way, the cars approaching from behind will be able to react much more quickly than if they had to wait for the brake lights to come on. Or imagine heavy rainfalls – poor visibility, slippery roads. How convenient would it be if your car knew at an early stage whether there was a risk of hydroplaning on your route. In such difficult situations, communication between cars helps to manage one or the other complex situation more safely. In a group of vehicles, information about dangers and the flow of traffic is disseminated from one car to another.

Like pearls on a string

Automated and connected driving will not only change road traffic. To take into account increasing freight movements on our roads, we must also use the potential inherent in intelligent transport technology. One of the solutions is truck platooning. The first truck determines the speed and all the others follow. If the first truck hits the brakes, the others do the same. Automatically. Since the response time is very low, these trucks are able to travel in a row with minimum distance from each other. This not only leads to more space on our motorways, but the trucks save fuel as well. First real-life tests are very promising. Now, an introduction strategy for truck platooning is being prepared at the European level.

Satellite navigation is an essential pillar for automated and connected driving. Today’s navigation systems can already follow your vehicle’s position in real time. In addition to the Global Positioning System (GPS), the European Galileo system will also be available in the future.
In the future, our cars will adapt their speed automatically in a way that will make them hit as many green waves as possible. How will they know at which speed to travel? This information will be provided by intelligent traffic lights, which will communicate with the vehicles. Not only traffic lights, but also traffic signs, parking lots, monitoring stations for traffic volumes or tunnel surveillance cameras will transfer information to vehicles. Even bridges will inform drivers if they are icy in winter. Based on this additional information, vehicles will be able to adapt their speed and choose an appropriate route so that you and your family can reach your destination safely. For the people living in towns and cities, improved traffic flows and an economic driving style translate into better air quality, less noise and reduced emission exposure. To be able to offer all this, it is necessary to have nationwide high-speed broadband internet, also via mobile telephony, so that information can be transferred reliably in real time. This is another area the Federal Ministry of Transport and Digital Infrastructure is intensely working on within its broadband deployment programme.

Before new applications go into mass production, they must be tested extensively. The A 9 Digital Motorway Test Bed provides the research community and industry with the best conditions for testing innovations related to mobility of the future under real-life conditions. To this end, Germany’s first fully digitalized road is being built in Bavaria on the A 9 motorway. Universal LTE coverage – and in the near future also 5G – as well as numerous other technical aids will allow us to further optimize products and services beyond computer models, simulations and outside laboratories in real world operations. Additional test beds are being established in Berlin, Braunschweig, Dresden, Düsseldorf, Hamburg, Ingolstadt or Munich to gain experience in urban areas as well. Automated and connected driving must also function across national borders. To ensure this, a cross-border test bed is being established between Merzig in Saarland and the French city of Metz.
Using all senses

**SATELLITE RECEIVER**
receives positioning signals

**DIGITAL MAP SYSTEMS**
are a high-precision key technology for automated and connected driving

**CAR2X-COMMUNICATION TECHNOLOGY**
allows the exchange of data between cars or between cars and infrastructure via Wi-Fi or mobile telephony, in particular data related to traffic flow or safety (traffic jams, end of a tailback, temporary roadworks, accidents, black ice, etc.)

**TRAFFIC SIGNS ARE RECOGNIZED**
by video cameras and image recognition and transferred to the driver and the vehicle

**CRASH SENSORS**
or surround sensors warn drivers of accidents and mitigate possible accident consequences

**KEY-PARKING**
means: drivers leave the vehicle and let it park in the spot by using their key

**TRAFFIC JAM ASSIST**
keeps the car in its lane and at an appropriate distance from the vehicle in front

**MONO AND STEREO CAMERAS**
support the detection of obstacles and potential safety hazards such as vehicles and persons

**RADAR**
measures distance and relative speed, based on microwaves

**ULTRASONIC SENSORS**
measure distance in the immediate vicinity

**LIDAR – LIGHT DETECTION AND RANGING**
measures distance and relative speed, based on ultraviolet or infrared rays or visible light

**INFRARED CAMERA**
allows for night vision systems with person and wild animal recognition
Automated and connected driving changes the way we move. Drivers as well as manufacturers and insurers therefore need clarity as to which rules are going to be applicable in the future. For instance, who will be responsible if a car causes an accident? Drivers must also know what they are allowed to do while the vehicle is in motion and what not. To ensure clarity, the Federal Government has developed the world’s most innovative road traffic law and a reliable legal framework for conditional and highly automated driving functions. Based on this law, in the future, under certain circumstances during an automated driving phase, drivers may rely on the functioning of the system and, in the case of a system failure, will not be held liable. In order to clarify violations and accidents, there will also be a special data storage device (black box). This black box will make it possible to determine whether the driver or the system was in charge at the time of the accident.

Surely

We need stringent international standards to protect vehicles against manipulations and cyber attacks. Hackers must not stand a chance. We need the best and latest encryption technologies so that systems and data are protected at all times. In addition to reliable software, users need to know what happens to their data. This means:

Drivers must be informed about which data is collected for what purpose and, where possible, be able to choose whether and with whom they want to share this data.
Assisted Driving
The driver permanently performs either lateral or longitudinal control. The other task is performed by the system within certain limits. The driver must constantly monitor the system. They must also be ready to assume full control of the vehicle at any time.

Partial Automation
The system performs both lateral and longitudinal control of the vehicle for a certain period of time or in specific situations. The driver must constantly monitor the system and be ready to assume full control of the vehicle at any time.

Conditional Automation
The system performs both lateral and longitudinal control of the vehicle for a certain period of time or in specific situations without having to be constantly monitored by the driver. If required, the driver is prompted to resume the driving task with a sufficient time buffer. All system limits are automatically recognized. However, the system is not able to establish a minimal risk condition in all situations.

High Automation
The system performs both the lateral and longitudinal dynamic driving task in all situations in a defined use case. The driver does not need to monitor the system. Before exiting the use case, the system prompts the driver, with a sufficient time buffer, to assume control over the vehicle. If this does not happen, the system goes back to establishing a minimal risk condition. All system limits are recognized by the system. The system is able to re-establish a minimal risk condition in all situations.

Full Automation
When a vehicle is fully automated (driverless), it performs the entire dynamic driving task in all situations and all speed ranges. The human becomes merely a passenger, since the system has full control over the vehicle.

Driver Assistance Systems
Many vehicles are already equipped with sensors, cameras and driver assistance systems. They inform drivers, warn them and in certain situations actively intervene in the driving process. There are electronic assistance systems such as adaptive cruise control or emergency braking, accident and traffic sign recognition as well as lane keeping, lane changing, high beam, parking or speed limit assistants.

Car-to-Car Communication
It is also known as Vehicle-to-Vehicle (V2V) or Car2Car communication. Vehicles communicate with infrastructure. For instance, real-time information on maximum speed near a road works site or an accident can be communicated to the vehicles/drivers. Based on this information, they can adapt their speed so that the traffic flow is not interrupted. Vehicles can transfer real-time information on the flow of traffic, too, thus helping traffic management centres to better manage traffic.

Car-to-Infrastructure Communication
It is also known as Vehicle2Infrastructure (V2I) or Car2Infrastructure communication. Vehicles communicate with infrastructure. For instance, real-time information on maximum speed near a road works site or an accident can be communicated to the vehicles/drivers. Based on this information, they can adapt their speed so that the traffic flow is not interrupted. Vehicles can transfer real-time information on the flow of traffic, too, thus helping traffic management centres to better manage traffic.