> New autoMobility

The Future World of Automated Road Traffic

acatech (Ed.)

acatech POSITION PAPER

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SUMMARY

With view to the major progress we have made in the field of driver assistance systems (DAS) and higher automation features in vehicles in recent years, today's mobility concepts require rethinking. In other words, we need to define the requirements for our future transportation system. Automation and connectivity of future modes of transport can contribute to a higher quality of life and more traffic safety on the road. The combination of electric mobility, technologies for intelligent vehicle control and transport infrastructure can reduce the negative side effects of mobility, such as noise and air pollution and, on the other hand, minimise the number of accidents on our roads. Automated road transport also makes mobility more accessible, facilitating possibilities for social participation – a particular challenge in times of an aging society.

The vision of marketable driverless vehicles will, indeed, be feasible and realisable in the foreseeable future, at least in certain regions. We will witness a situation of mixed traffic where vehicles with various degrees of automation as well as the classical manual ones operate alongside on our streets. In view of the current rapid developments in the field of automated driving, the Federal Ministry of Transport and digital Infrastructure joined forces with acatech to launch the project group *New autoMobility*. The present position paper outlines some of the project group's results. The authors present the target scenario "The Future World of Automated Road Traffic" for the period beyond 2030, illustrating the advantages of innovative mobility solutions and focusing on the users' requirements.

With view to the numerous interfaces with cross-cutting issues and the heterogeneity of the actors involved in the mobility ecosystem, we first undertook a schematic description of activities necessary for the implementation of the target scenario. The issues addressed mainly touch questions of technological feasibility and economic viability. Only if we make the right decisions regarding the future design of vehicle technology can we benefit from the opportunities inherent to a *New autoMobility*. Here, the key focal areas are intelligent vehicle control, vehicle-connectivity, IT-security and intuitive human-machine interaction. The groundwork is provided by evolutions in the fields of sensors, camera technology and localisation. The increasing automation in road traffic enhances the additional value of digital connectivity, such as the communication between vehicles and traffic light controller systems. This, in turn, entails the need for cross-sector cooperations between the different actors involved in automated road traffic, be it from the perspective of R&D, as supplier or as user. Moreover, the ubiquity of data-related issues when addressing automated road traffic reveals a major need for a discussion about different overarching questions. These include, for instance, the question of how a future connection between different forms of mobility could be effected, how the legal framework must evolve and how the debate on ethical issues should be conducted. As part of a comprehensive innovation programme, Living Labs offer various opportunities to also analyse issues of public acceptance.

Both the traditional producers and the suppliers of new mobility services need to develop innovative solutions in Germany and prove their worldwide competitiveness. This is a necessary precondition not only for securing sustainable jobs but also for Germany to establish itself as leading supplier and lead market in this field. As an important centre of the automotive industry, it is up to Germany to initiate a debate on framework conditions at the national and European level in order to pave the way for the *New autoMobility*.

It became clear from the start in the discussion of the target scenario that a concerted effort cannot wait until the end of 2016. The acatech position paper outlines a first basic agreement on the subject across various disciplines and sectors. In line with its mandate, it particularly addresses policy makers and the civil society. About thirty institutions from science, politics, industry and associations have joined forces to draw up a vision of automated road

traffic for the year 2030 and beyond. The target scenario they developed constitutes the foundation for an in-depth study acatech will undertake in 2016. In the second stage of the project starting in autumn 2015, the participating sectors and disciplines will develop a roadmap for the period up to 2030. This will include substantiating the steps necessary to achieve the target scenario and identifying measures within the different fields of action. Next to the technical and economic analysis of innovative vehicle technologies, the acatech study will also treat issues arising in the context of socio-cultural developments.

RECOMMENDED ACTIONS IN SUMMARY

1. Merging automation, connectivity and infrastructure into a comprehensive approach

Creating connectivity between vehicles and the infrastructure as well as merging traffic management systems and cloud-based services into an integrated approach significantly increase the merits of pure automation. Thus, particularly comfort and traffic flow can be further improved. In addition to technical developments, uniform standards for communication and cooperative decision-making between traffic participants must be established. Moreover, an early upgrading of the traffic information and communication infrastructure is required.

2. Incremental evolution towards automated traffic

The establishment of automated road traffic requires a phased development plan including scenarios showing possible effects of an introduction of mixed traffic. We further need carefully planned incentives to effectively control and steer transport demand.

3. Establishment of Living Labs

The development, testing and evaluation of automated road traffic integrating both the various means of transportation and the traffic participants requires duly equipped Living Labs and test centres.

4. Development and introduction of standard principles for human-machine interaction in the automotive sector

German producers, research institutes, auditing organisations and federal authorities should play a leading role in the development and establishment of international standards for security-related human-machine interaction in the automotive sector.

5. Data processing for automation and connectivity

Automation and connectivity depend essentially on the collection and processing of data and information from various sources. Here, we will have to develop models of data usage allowing all persons or institutions involved to resort to attractive and successful business models while respecting the personal interests of the users. Suitable framework conditions should facilitate interoperability between platforms.

6. Active development of the legal framework

In order to pave the way for successful market launches in the field of automated road traffic, regulatory decisions are required at the national and international level. The basic question in this context is how the legal framework must evolve to best ensure the necessary legal security for the development of automated road traffic.

7. Launching an innovation programme for the automated road traffic of the future

In times of increasingly automated road traffic, keeping up the control and influence in questions of technological innovations requires investments in innovative research and development. A focal point should be to foster interdisciplinary research networks between universities, research institutions and companies by establishing coordinated support programmes.

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1 INTRODUCTION

Mobility is a basic human need. It is a prerequisite for personal freedom and facilitates social participation even beyond the immediate surroundings. The mobility of people and goods is the basis of a dynamic economy and society and thus contributes significantly to improving the quality of life and social welfare.

However, the desire for mobility increasingly encounters limits: not only does the demand for mobility of people increase; it is also the demand for the transportation of goods that rises owing to the progressing international division of labor. Thus, we witness a rising demand for fossil fuels and other resources used for the transportation of goods and people, while their availability decreases. All over the world, urban areas are growing denser. The ensuing increase in traffic generates noise, causes congestions and increases the risk of car accidents. Mobility also causes smog and an accumulation of pollutants in the air. One look at the current situation is sufficient to show just how much potential for improvement automated road traffic harbours. Automated vehicles can prevent accidents, avoid traffic jams and reduce energy consumption. Driverless local transport can give independence to people nowadays suffering from reduced mobility. For such developments, new mobility concepts play a central role.

With the advent of digitisation, value chains and business models change at breathtaking pace. The mobility sector is no exception. While the German industry is technology leader in the field of vehicle technology, it is US internet companies that pioneer in the field of data and information. Germany needs to take the initiative if it wants to build on its global leadership in mobility technology to actively shape future developments. Only thus will we succeed in promoting mobility solutions reflecting our social and legal values and in securing value creation in the mobility industry.

Ultimately, all this will not be possible without public acceptance. A coordinated approach in the field of public relations should provide the future participants in automated road traffic with information about the new technologies at an early stage. They should also be involved in the actual research procedures –for example by means of Living Labs.

THE FUTURE OF TRANSPORT: FROM MANUAL DRIVING TO AUTOMATED, DRIVERLESS TRAFFIC

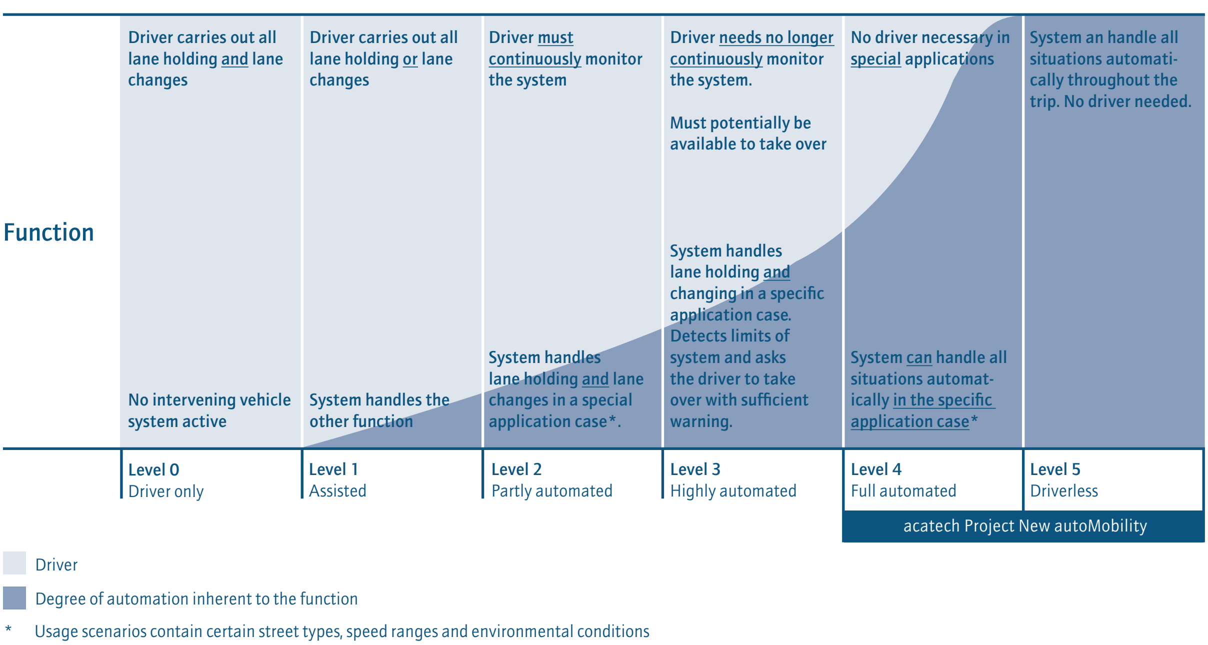
The POSITION PAPER outlines the first results of an agreement sought across various disciplines and sectors in the acatech project *New autoMobility*. The jointly developed target scenario of a multi-modal transportation system for the period beyond 2030 considers different requirements and visions in the fields of automation, connected driving and the Internet of Things, data and services. The vision evolves around the central feature of automated driving; however, automation and connectivity of vehicles must generally be seen in the greater context of a comprehensive transformation of our mobility system.

Even today, vehicles – newer ones in particular – are equipped with numerous assistance systems. The broader the scope of functions offered, the higher the proportion of the automated vehicle system (ranging from level 0 to 5, cf. figure 1) and the fewer the tasks incumbent on the driver. Basically, it can be distinguished between manually steered vehicles (without automation functionality), automated vehicles (with a range of different functions) and driverless vehicles (without steering wheel and pedals). With regard to the levels of automation, this paper resorts to the accepted categorisation established by the Federal Highway Research Institute (BAST) under the title *Legal consequences of increasing vehicle automation*. Also, the results from a Round Table on Automated Driving initiated by the *Federal Ministry of Transport and digital*

Infrastructure (BMVI) were used for the present analysis. Important input for the standardisation of automation levels was also provided by the *Society of Automotive Engineers* (SAE). However, the target scenario in this position paper reaches into a future well beyond the stage of high automation. It attempts to indicate different possibilities of how a mobile transportation network of the future could be designed to enable, under certain conditions, fully automated (Level 4) as well as driverless transport (Level 5).

Accordingly, the project group developed usage scenarios on the basis of the target scenario. They reflect the different requirements of automated or driverless transport systems. Combined with automation features, digital technologies provide additional benefits – from an economic perspective as well as for the public. A future-orientated target scenario therefore requires the merging of automation and connectivity into a comprehensive approach. This implies initiating according cooperations to foster the synergy potentials. The present acatech position paper aims at objectifying the debate. In the second stage of the project, the working group will develop a roadmap substantiating the strategic decisions necessary within the different fields of action. This will constitute the basis for the next steps on the path towards a *New automobility*.

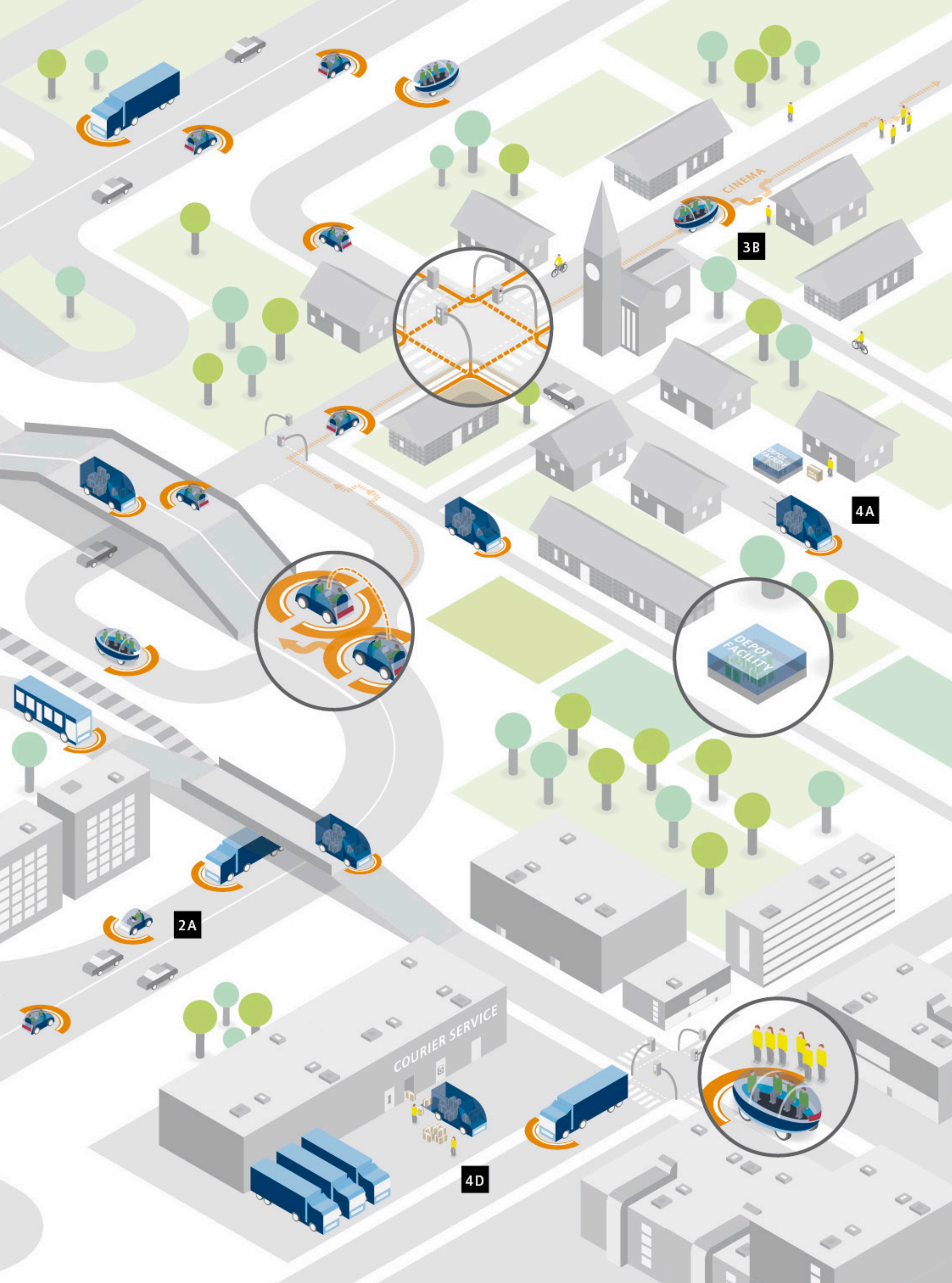
Figure 1: Levels of automation



Source: BMI/VDA/own illustration

Figure 2: Target scenario
„Future World of Automated road transport"
(Source: own illustration)

The magnifying glasses indicate general functions and processes inherent to the target scenario.


CINEMA
3B
4A
DEPOT FACILITY
2A
COURIER SERVICE
4D

2 TARGET SCENARIO

Multimodal mobility presents numerous economic, environmental and social challenges. This is true from a present perspective and will doubtlessly continue in the future. Automated road traffic and driverless vehicle control can contribute significantly to overcoming the current problems arising from multimodal mobility. The target scenario with its several usage scenarios resorts to exemplary situations to illustrate the benefits to be expected from automation and connectivity. These regard the quality of life, social participation, traffic safety and issues of public welfare.

2.1 QUALITY OF LIFE

Mobility contributes to climate change and affects the quality of life by noise, air pollution and the appropriation of areas for e.g. parking space. This applies particularly to urban centres. In combination with electric mobility, intelligent automation can considerably reduce the negative side effects of mobility, bringing us a decisive step closer to the ideal of a sustainable city of the future. This is achieved by expanding the road infrastructure – currently based on the requirements of the current local public transport system – through a more efficient and hence more economical use of parking and road space as well as by reducing energy consumption. Fewer congestions and improved traffic light settings, for instance, contribute significantly to a reduction of energy demand.

Entrepreneurial innovation flourishing in the context of the development of new technologies and business models likewise entails an improved quality of life for each and every individual. The example of car-sharing platforms shows that even today, users increasingly regard mobility as a service. The interconnectedness of traffic participants via internet-based applications allows for individualised services, which offer the user *mobility on demand*. Electrified and automated car sharing harbours huge potential for resource-efficient mobility in urban centres and beyond.

Automation also offers great advantages to the three million German commuters, especially those who cover more than 25 kilometers by private car every day. By reducing congestions and allowing for a better predictability of travel times, automated road traffic can substantially lower the stress level for traffic participants. Moreover, the time spent in the car can be used either for leisure time or as working time. Overall, we spend less time with professional and job-related duties.

2.2 SOCIAL PARTICIPATION

Automated traffic can also contribute significantly to the fulfillment of individual needs because easier access to mobility facilitates participation in social life. Germany is facing a major social change: While the overall population is shrinking, the percentage of elderly people is rapidly increasing. According to forecasts, the over 65-year-olds will account for almost one-third of the total population by 2030. In 2060, the largest cohorts are expected to be found amongst the age group roundabout seventy. Elderly or disabled people as well as children are often greatly limited in their mobility behaviour. This group of traffic participants can benefit from a future mobility network in terms of better access to mobility services or a better supply with goods and services. This will be of particular relevance in rural areas that are already suffering from increasingly scant municipal services regarding medical care, shopping and local public transport services. The odds are that this trend will become even stronger in the future, because the demographic decline in these regions will be much more pronounced than in urban centres.

2.3 TRAFFIC SAFETY

Despite the overall increase in traffic volumes, the number of injured traffic participants in Germany has been declining for years. Even so, still more than 392,000 people are involved in traffic accidents every year (2014). Almost ninety percent of the accidents are caused by human errors. Thirty percent of the fatalities occur amongst the group of "weaker" traffic participants, i.e. pedestrians and cyclists. Despite all improvements, still 354 cyclists were killed in 2014. Connectivity between transport modes as well as sensors in automated vehicles can considerably defuse the perilous situations mainly responsible for these accidents. Hence, the overall number of accidents could be reduced by well over fifty percent.

It is mainly owing to advanced security systems that this development is possible. Recent statistics of vehicles equipped with standard emergency braking systems confirm a reduction of rear-end collisions by 28 percent. Even with increasing traffic volume, automation and connectivity will play a crucial role in reducing the number of accidents on our roads. This would be a decisive step towards realising "Vision Zero", the vision of road traffic without fatalities.

2.4 ENHANCING COMPETITIVENESS BY MEANS OF INNOVATIVE BUSINESS MODELS

Overarching trends such as the automation of transport modes and their connectivity with the transport infrastructure generate new mobility solutions for the future road traffic. Similarly, social developments such as sharing, i.e. the systematic sharing or borrowing of goods, are promoted by digital platforms and social networks. The demand for new mobility solutions creates new markets which, from an entrepreneurial point of view, must be made accessible by means of innovative business models.

From the perspective of the worldwide leading automotive industry in Germany, automation and connectivity offer opportunities for the successful expansion of their range of products. This also includes the respective suppliers and service providers. Operators of digital platforms and service providers offering comprehensive mobility solutions for automated and connected road traffic are playing an increasingly important role in the supply chains. As hotspot for technological development and innovation, Germany needs to secure sustainable jobs. Here, both traditional producers as well as suppliers are asked to develop innovative mobility services and prove their worldwide competitiveness.

2.5 PUBLIC WELFARE

The automated road traffic of the future offers great individual benefits by improving the availability of public transport and logistics services which in turn result in positive welfare effects. In this context, the reduction of the annual costs incurred by congestion and traffic accidents must be particularly mentioned. According to a recent estimation (2013), traffic accidents account for annual costs of about 32 billion euros. Also, a car stuck e.g. in stop-and-go traffic consumes more than twice the amount of energy of a car travelling at 130 kilometers per hour on a clear road. Incidentally, automation in road traffic can reduce the overall mileage. Every kilometer less lowers the costs incurred by environmental pollution, accidents and an increasing traffic density that negatively affects all parties involved. The time individually gained as a result of improved traffic flow and automation also increases the productivity of both professional drivers and commuters and frees time for the pursuit of personal activities.

2.6 CONCLUSION: OPPORTUNITIES OFFERED BY *NEW AUTOMOBILITY*

Innovative, competitive products and services, cost reductions and a more efficient use of the valuable resource time can contribute to higher economic productivity and create public welfare. In the long term, we can thus secure jobs in the German high-wage economy and enhance the quality of life. This implies a firm commitment to actively shaping an increasingly connected and automated road transport as part of our future mobility. Only thus will we succeed in developing future mobility solutions reflecting our social values. *New autoMobility* entails an improved quality of life, greater security and new opportunities for social participation.

3 USAGE SCENARIOS

The following scenarios show in detail how the technologies featuring in the target scenario can be used to good effect in different contexts of users' daily lives. Here again we will cover the aspects of quality of life, social participation, security and added value – this time, however, focusing on the perspective of the users with their individual needs. Basically, the scenarios deal with road safety for pedestrians and cyclists; with possible uses for the time on the road; with redesigning urban space by introducing resource-efficient local public transport shuttles (LPT-shuttles) and logistics services.

3.1 SAFELY ON THE ROAD ON FOOT AND BY BIKE

Information and automation systems increase safety considerably, especially for pedestrians and cyclists. The main cause of accidents between cyclists and motorists are errors when turning right. In ninety percent of the cases, the responsibility lies with the motorist. Eighty percent of the accidents result in injuries. Accidents also occur frequently while merging or changing lanes, or as a result of suddenly opening car doors in parking strips along roadsides. In all these cases, sensor-based automation can greatly reduce the risk of accidents. The additional use of telematic connectivity allows for timely evasive manoeuvre even in the case of pedestrians suddenly appearing on the streets from behind whatever might have been screening them from view.

1A

9:30 a.m., Wiesbaden street corner Südwestkorso. A 63-year-old cyclist crosses the road, the traffic signal is green. A truck driving next to him turns right; a collision between the cyclist and the truck is imminent. The crash is prevented by the in-vehicle control system. The cameras and other sensor systems with which the truck is equipped, detect the cyclist. The system can be relied upon even if one of its features fails, for instance because of difficult environmental conditions. The braking system is automatically activated.

Usage scenarios 1A – 4D please refer target scenario page 11–12

1B

12:30 p.m., Without warning, a seven-year-old boy runs onto the street from behind parking vehicles. He is in danger of being hit by a 43-year-old motorist. However, the oncoming vehicle, having a different field of vision, has registered the boy early on and sent a warning to the oncoming traffic. Connectivity enables automated and driverless vehicles to predict the probable direction of motion of all moving traffic participants, making it possible to identify potential collisions at an early stage. If a risk of collision is detected, other vehicles are warned, enabling them to avoid an accident by braking early or performing evasive maneuvers. A rear-end collision with following vehicles is likewise avoided, as the respective motorists are warned via camera information and vehicle-to -vehicle communication.

1C

1:00 p.m., Prenzlauer Allee. A motorist prepares to open the door of her vehicle, while a 17-year-old cyclist is passing on the cycle lane. The imminent accident is prevented, because the cameras of the car detect the cyclist in time and warn the driver accordingly.

1D

3:30 p.m., corner Friedrichstraße/ Mohrenstraße.
A 35 -year-old cyclist using the road due to the lack of a bycicle path, signals to the car behind him his intention to turn left. There is no uncertainty as to whether the driver registers his intention and will throttle the pace accordingly. Via external display elements fitted into the vehicle front, the car signals to the cyclist that the system has registered him and that he can now safely merge into the left lane to cross the roadway.

3.2 EXTRA TIME

The fully automated control of private vehicles over long distances and on motorways allows the driver to use the time on the road productively. In addition, the conjunction of automation and connectivity can significantly optimise the traffic flow. Automated parking services ("valet parking") in combination with intelligent parking guidance systems can also significantly shorten the search for parking spaces and enhance the efficient use of available parking space. Particularly in the metropolitan areas, this reduces the considerable traffic volume due to vehicles cruising for parking and facilitates the switching between different modes of transport.

Yasar B., 43, is chief physician at the Hospital Munich West. A few years ago he moved to a suburb in the north of Munich with his wife and three children to escape the bustle of the city centre. The change of residence had the further advantage of significantly shortening the work-related trips his wife has to undertake for her job as management consultant.

A typical working day begins with Yasar B. dropping his children at play school and school, before continuing his way to work on the city highway ring. He is now free to attend to a few morning tasks without interruption. To this end, he switches to the automatic mode once he has reached the motorway. He orally communicates his destination to the automation and confirms his choice of the travel mode. As usually, Yasar B. chooses the mode "comfort", which allows him a comfortable ride. The steering wheel disappears into the dashboard. The driver's seat moves back. A desk top slides out of the centre console.

2A

At 8:40 a.m., Yasar B. logs into the hospital server from out of the car. His working day begins. The nurses have already updated the patient data recorded that morning: progress of treatments, laboratory results, nutritional data and indications of possible complications. Until his arrival at the hospital, Yasar B. has half an hour time to study and comment the data, give instructions and, if necessary, search the system for comparative data in order to assess individual cases.

During this time, steering, route selection and speed adjustment are fully taken over by the autopilot. Although Yasar B. travels at a peak time, the speed is curbed only in a few sections of the route. As vehicles are connected with one another as well as with the urban traffic control centre, their movements are coordinated which significantly optimises the traffic flow. On the bypass, too, the traffic flow is rapid: Owing to automatic speed adjustments and the situational control of traffic light cycles, most traffic participants benefit from almost continuously phased traffic lights. Connectivity allows for the immediate registration of road damages and accidents in the system and the according adjustment of the routes.

In due time before reaching the highway exit, the autopilot transfers the control back to the driver, as the last kilometers of the route are not yet certified for the automated driving mode. The standardised and intuitive interaction principles found, with only slight variations, in all types of cars, allow the driver to safely and quickly resume control of the vehicle. The autopilot sign, clearly visible from the outside, is turned off.

For the last few kilometers to the hospital grounds, Yasar B. performs the usual driving task himself. At the entrance of the rambling complex of buildings, he grabs a bag containing his valuables and a small snack.
With his smartphone, he activates the feature "Valet Parking". The car moves on at walking pace, visibly communicating that it is in the "driverless" mode. It drives towards the nearest underground car park which, incidentally, accommodates one third more vehicles since the introduction of automatic parking.

Yasar B. leaves the hospital grounds around 4:30 p.m. to find his car, the battery fully charged, waiting in the entrance area. Yasar B. uses the travel time to continue his work. Shortly after 5 p.m., his eight-hours working day is over and he is already back home, where he can now devote himself to his children.

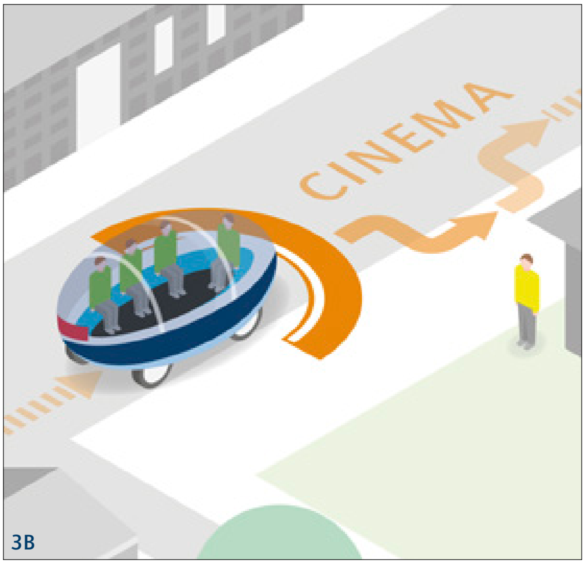
3.3 NEW FLEXIBILITY IN PUBLIC TRANSPORT

A mixture of car pool, taxi and car-sharing, the automated public transport shuttle brings its passengers safely through the traffic. Depending on the specific purpose it fulfills and on the local demand structure, the public transport shuttle has between two and ten seats. Step by step, the road network is developed for the requirements of public transport shuttles. Passengers board the shuttle at one of the many virtual stops marked on an online map. At these virtual stops, passengers can get on and off the shuttle without disrupting the surrounding traffic. The shuttle is able to automatically calculate an optimal route combination for different passengers and to predict the travel time in advance and with high accuracy.

3A

Maria P. ,72, single, lives on the outskirts of Bielefeld. Every few weeks, she visits her daughter and three grandchildren in Hannover. By train, Hannover is at an easy distance and, owing to the Senior Railcard, the ride is affordable, too. The problem, however, is to get to the train station. By public transport, the ride is rather lengthy and cumbersome – especially with luggage – and a taxi would be more expensive than the train ticket.

Therefore Maria P. orders a public transport shuttle. It is almost as fast as a taxi, but is only about half the price, as empty runs are avoided and no driver is kept on stand-by. The virtual station, where the public transport shuttle can smoothly stop and Maria P. can easily board is conveniently situated at her front door.



3B


3C

77-year-old Werner M. lives in a small village in Lower Saxony. Before his retirement, he was much on the road for his job as a sales representative. A few years ago, however, he decided he would no longer drive at night. Eventually, when the last major car repair was due, he resolved to give up his car altogether. His modest pension scarcely suffices to cover the maintenance costs of the car anyway. Since gradually even rural areas are being developed for driverless driving, he now uses the public transport shuttle. In the countryside, the shuttle works like a car pool. Werner P. defines a period of time within which he would like to travel a certain route, along with the maximum price he is willing to pay. The appointment application of the local public transport provider will automatically calculate the best options and books the trip according to the preset profile. Since the public transport shuttle went into operation, a cinema and a pub have reopened in the neighbouring village. Guests from the surrounding villages can reach them easily and at a reasonable price without requiring a car of their own.

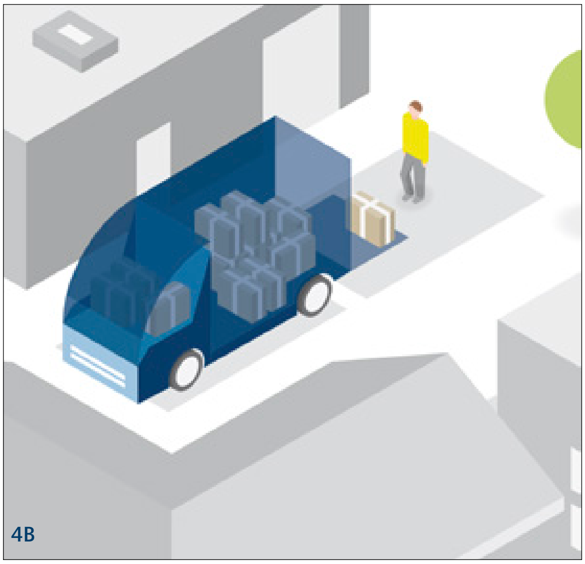
Anja H., dental assistant, 35, lives in a central borough of Berlin. Even though her apartment is at an easy distance from the underground and the city train railway network, there are neighbouring districts that are cumbersome to reach owing to the lack of viable cross connections. This is, for instance, the case for her workplace. Depending on the weather and her individual mood, Anja H. either takes her bicycle or uses the public transport shuttle to go to work. Via an app on her smartphone, Anja H. can choose between two options for her ride on the public transport shuttle: the more expensive solo shuttle or the cheaper carpool-version. The latter might involve a detour to bring another passenger to his or her destination or to a transfer point. However, the shuttle invariably arrives within the pre-calculated travel time. For Anja H., the public transport shuttle is much more convenient and faster than the bus she used to take for that route. And while she could use her own car, it would be financially disadvantageous as parking fees at her destination would exceed the price for the shuttle ride.

3.4 BETTER SUPPLY

Driverless delivery allows for a complete restructuring of the last step in the transport chain, the delivery to private and commercial customers. Automatically controlled transporters deliver their parcels to stationary deposit facilities or to mobile "deposits on wheels" that can be ordered to drive up to private and commercial customers in city areas. Automated vehicle control resolves many of our typical delivery problems: For instance, transportation times are reduced, making a higher delivery frequency possible. Distribution hubs in the city centres allow for new business models, particularly in the food sector. For courier services, driverless vehicle fleets constitute a cost-efficient alternative for short-term small-distance deliveries. This opens new vistas for local service providers. Optimising long-distance transport by means of driverless trucks constitutes an important pillar of these new business models. All in all, the entire transport chain gains in speed and efficiency.

4A

Ernst and Hilde O., both approaching their eighties, live in the country in a village with 2000 inhabitants. The small village supermarket has long since closed. The nearest shopping facilities are now thirty kilometers away. For the past few years, the old couple has been using the services of an automated deliverer, daily bringing a shopping basket to their private deposit unit in their front garden. The basket is filled by a supermarket the product range of which Ernst and Hilde O. know well. It is then dispatched by the standard post. Owing to driverless transport systems, producers, processing companies and wholesalers can supply the supermarket with a very wide range of products. Thus, even customers from peripheral areas can chose from a comprehensive assortment of goods. As adequate cooling is provided throughout the entire supply chain and the transportation from the supermarket to the end customer does not take more than half a day, even perishables do not present a problem. Three times a week, the couple has domestic help, supporting them in the planning of errands and the preparation of meals. For trips to the cinema or the regular games evenings at their friend Werner M.'s place, Ernst and Hilde use the public transport shuttle.



Andreas M., in his early thirties, is sales manager in a fashion company. He travels a lot and often returns from work rather late in the evenings. Therefore he does the bulk of his shopping online. There are no neighbours to receive the parcels from the different courier services. Hence, Andreas M. has all parcels dispatched to a central delivery point in his district. Once he is at home, he arranges for the parcels to be delivered via a mobile deposits unit. The driverless delivery service comes right up to his house and Andreas M. can receive his purchases.

Michaela and Sören K. are in their mid-thirties and have two preschool-aged sons. They set great store by a balanced diet and organically produced products from the region. Although there is large-scale fruit cultivation in the countryside around Berlin, it used to be rather difficult to buy regional products in the shops at affordable prices, as the small producers were not included into the wholesale supply chains. However, since driverless services reduced the delivery times to a few hours, even fresh produce can be delivered at favorable conditions via the usual post delivery network. Hence, three times a week Michaela and Sören K. receive a delivery directly from "their" farmers in the country. This saves them the otherwise necessary trips through the city to pick up the comparatively small quantities while the food remains affordable despite the small quantities in which it is traded.

Svenja T., 51, runs a courier service with a fleet of driverless delivery vehicles on the southern outskirts of Cologne. Her regular customers include laundry and catering services and other service companies providing personalised services for customers in the borough. The rising commercial rents in the city centre obliged many small service providers to move away from the neighborhood, as they could no longer afford their premises. A few kilometers into the periphery, the situation is much better. By providing intelligent route management, Svenja's direct driverless delivery service also enables the service providers to attend to a large network of clients speedily and at affordable prices. This is not least due to the fact that late in the evenings and at night, Svenja T. can resort to the local public transport shuttles, which are then little used and accordingly cheap.

4 CURRENT STATUS AND FIELDS OF ACTION IDENTIFIED

To realise the target scenario, a systematic and consistent approach is required. This includes taking the current state of research and the requirements derived from it into account when developing fields of action and recommendations. In the following chapter, exemplary projects and initiatives will be outlined that contribute to a wide range of knowledge in the field of automated driving.

4.1 RESEARCH AND STUDIES

Numerous national and international research projects have already been devoted to the automation of the vehicle control system. The results and scenarios these projects yielded are taken into account in the present position paper. As early as 1986-1994, an intelligent cruise control was developed in the EUREKA research program *Prometheus*. Five years later, European manufacturers successfully installed the device as adaptive cruise control (ACC) in serial products. Both the speed and the scale at which new assistance systems have since been developed and introduced have increased rapidly. For this, EU-projects like PReVENT, HAVEit, interactIVe or adaptIVe are eloquent examples. In these projects, numerous features pertaining to manual and automated driving continue to be explored. They aim at supporting the traffic on motorways, country roads and in cities and are applicable in uncritical situations as well as in emergencies. Legal aspects and issues touching on human-machine interactions are likewise addressed. In the project *Automation in Society – Highly Automated Driving (ASHAD)* carried out by the Technical University of Munich, scientists from various disciplines examine success factors and barriers that bear upon the implementation of highly automated driving. The aim is to better understand the intricacies of complex socio-technical systems and to show the need for active communication with regard to social, ethical and cultural aspects.

As part of the future mobility system, automated driving is closely linked with parallel developments. The expert working group *Autonomous Systems*, a sub-panel of the *High-Tech Forum*, for instance, treats autonomous systems for industrial production, for smart homes and, in the mobility sector, autonomous systems for road and rail transport. Smart-City-projects, such as the *National Platform City of the Future* conduct their researches with view to the ongoing re-urbanisation and the efforts to increase resource efficiency in urban areas: What impact would autonomous transportation have on mobility in the City of the Future? What use can be made of mobility data or the connectivity of different transport services? The prerequisites a city must fulfil in terms of traffic information and communication infrastructure to enable automated road traffic are subject of a study at the national level conducted by the *Innovation Network Morgenstadt: City Insights (m: CI)*. With view to securing a high quality of life and resource-efficient mobility, the EU-framework programme *Horizon 2020* provides funding for various research projects; Smart-City projects alone are funded with over 100 million Euros this year.

In addition to the overarching research programmes, numerous projects address specific applications of automated vehicles in urban transport. Projects like *UR:BAN* realised by the *Federal Ministry for Economic Affairs and Energy (BMWi)*, the Innovation Lab *AutoNOMOS* of the Freie Universität Berlin or the project Stadtpilot initiated by the Technical University of Braunschweig consider urban scenarios in their research on assistance and automation systems. *Stadtpilot* is one of the first ever projects on driverless urban transport. Along with numerous vehicle functions, the Project *UR:BAN* is currently also examining features like intelligent road junctions and their interactions and connectivity with automated vehicles.

Initiatives increasingly broaden their scope of action from pure assistance and automation issues to questions of communication and connectivity. Whereas the national project *Safe Intelligent Mobility – Test field Germany (simTD)* focused on large-scale tests, the EU-projects *D3CoS* and *AutoNet2030* particularly tested the cooperative driving of several vehicles. These projects were accompanied by the establishment of large-scale facilities for research and testing, so-called Living Labs. The projects *UR:BAN* and *D3CoS*, for instance, resorted to the *Application Platform Intelligent Mobility (AIM)*. In the field of driverless systems, the EU-projects *CityMobil* and *CityMobil2* in particular yielded important research results regarding the implementation and testing of Automated Guided Vehicles (AGVs) in urban areas.

In addition to specific research results, the usage scenarios, fields of action and recommendations also take up aspects of previously created roadmaps and strategy papers for automated driving. The *Automotive Roadmap Embedded Systems of SafeTRANS*, for example, indicates current and future challenges for information and communication technologies in the automotive sector. Also, elements of the scenarios "Motorway Pilot", "Autonomous Valet Parking" and "Vehicle-on-Demand" that were developed in the project *Villa Ladenburg* (a project funded by the Daimler and Benz Foundation) are included in the usage scenarios outlined in the present paper.

Some ideas from the anthology *Autonomous Driving. Technical, legal and social aspects* (2015) were taken up in the target as well as the usage scenarios: The local public transport shuttles, for example, are the result of a logical evolution of the passenger transportation system we find there, which is likewise driverless and can be ordered individually. The scenario "Safely on the road on foot and by bike" resorts to options for optimising road safety by means of automated vehicle control that are likewise discussed in the anthology. The scenario "Improved Supply", which presents improved logistics, contains a vision of self-propelled delivery vehicles largely based on internal business surveys.

4.2 POLITICAL DISCOURSE AND LEGAL FRAMEWORK

In 2013, the BMVI set up a *Round Table on Automated Driving* in order to systematically tap into the potential of automated driving and bring about a national consensus on the key issues. Amongst the institutions involved are several federal ministries and federal authorities, federal states, industry associations, inspection organisations, users' associations, the insurance industry and relevant research institutions. The Round Table plenary assembly adopted a comprehensive report on the most important research needs. In addition, strategic cornerstones for further action were drawn up, which constitute the basis for the BMVI's national strategy for the evolution of automated driving. The strategy aims at enabling automated driving by 2020. In connection with connectivity and automated driving, the German Federal Government is currently also considering overarching issues of data protection and IT-security, regarding, for instance, vehicle-to-vehicle and vehicle-to-infrastructure communication. As a real-condition laboratory, the *Digital Test Area Motorway* on the A9 motorway creates a typical setting where connected and automated driving can be ideally tested. In view of the advancing automation of vehicle control systems it is incumbent to check the consistency of such systems with the provisions of the German Road Traffic Licensing Regulation (StVZO). Currently, clause 19 section 6 StVZO allows vehicle manufacturers in possession of an operating licence for prototypes to test vehicles technically capable of automated driving. Along with questions pertaining to the ownership of automated vehicles, there are liability issues to be settled. In this context, the project group of BAST Legal consequences of increasing vehicle automation has indicated open legal issues and identified research gaps in the fields of human-machine interaction and certification. The Federal Governement is also currently probing into questions of civil and criminal liability and of responsibility for administrative offences in the context of automated driving. Automated driving was also discussed at this year's Conference of the German Council of Transport Authorities (VGT). The subsequently published recommendations include adjustments to the legal framework and a clarification of the current clause on so-called non driving-related activities in the Vienna Convention.

At the European level, the technology platforms *European Road Transport Research Advisory Council (ERTRAC)*, *Ertico ITS Europe, European Council for Automotive R & D (EUCAR)*, *European Association of Automotive Suppliers (CLEPA)* and *European Technology Platform on Smart Systems Integration (EPoSS)* are key drivers of the dialogue between the scientific community, the industry and the public authorities. In addition, the *Working Group iMobility Automation* is developing a European roadmap for a harmonised introduction of highly automated functions in Europe. At the international level, an according legal framework is enshrined in the Vienna Convention on Road Traffic. Recently, the *Working Group on Road Safety* at the *United Nations Economic Commission for Europe* initiated its amendment regarding automated systems already in circulation. The so-called Road Safety Forum of the United Nations Economic Commission for Europe (UNECE) deals with the legal requirements for the implementation of automated traffic. Other countries also make legal provisions for automated traffic. For instance, since 2014, the U.S. National Highway Traffic Safety Administration (NHTSA) has been preparing a law obliging car manufacturers to fit new vehicles with vehicle-to-vehicle communication-technologies.

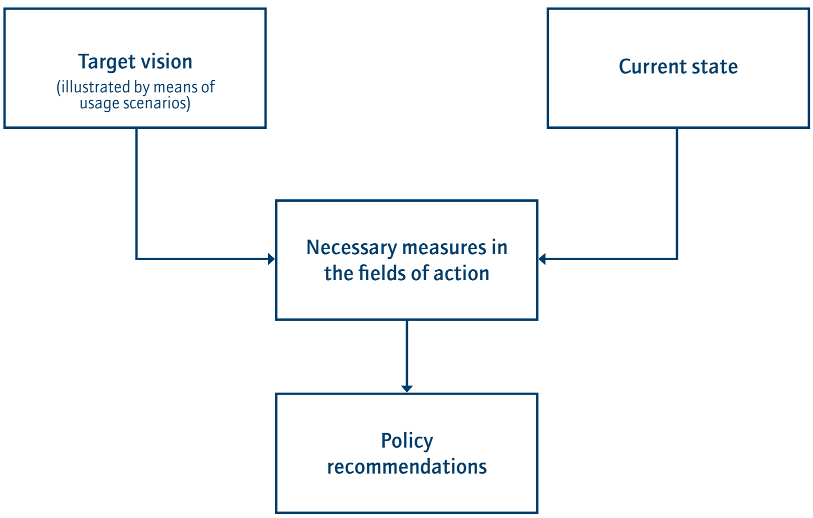
4.3 OVERVIEW OF DIFFERENT FIELDS OF ACTION

A synthesis of the target scenario the acatech project group *New autoMobility* developed in the form of usage scenarios and of the current state of research and development yields the fields of action outlined below. The project group has identified five overarching subject areas that provide the basic structure for working groups. These subject areas are research & development, standardisation, framework conditions, infrastructure and business models. In the second phase of the project, every subject area is assigned specific fields of action. On this basis, a subsequent acatech study will present a comprehensive roadmap with specific steps.

Figure 3: Identified fields of action for realising the target scenario

Source: own illustration

Figure 4: Development of the policy recommendations



Source: own illustration

4.4 METHODOLOGY

The usage scenarios were chosen and designed as to give a faithful picture of developments desirable with regard to quality of life, social participation, traffic safety and an increase of public welfare. This was ensured by basing the selection and design of the scenarios on current prognoses of what is technically possible in the foreseeable future. For the specific elaboration of the usage scenarios, a morphological analysis was carried out. By means of this creativity technique, a simplification of multidimensional problems is effected that allows their representation on a two-dimensional matrix. The aim of the morphological analysis was to assign individual parameters (such as "LPT" or "motorised individual transport (MIT)" or "senior citizens" or "working persons") to the different dimensions (such as "transportation operators" or "transported individuals or goods"), in order to obtain the fullest possible coverage of dimensions and parameters in the scenarios or at least in some aspect of them. An overlap of the parameters is possible. The policy recommendations indicate how the current state of R&D and regulation in the various fields must evolve to realise the target scenario.

Figure 5: Morphological analysis

	PARAMETER				
motivation	quality of life	traffic safety	social participation	competitiveness	public welfare
setting	motorway	city	country road	city traffic	urban areas/ rural areas
transportation operator	LPT	MIT	freight traffic	LPT	delivery services
information flow	vehicle equipment	surrounding infrastructure			
transported individuals or goods	senior citizens	working persons	parents	children	goods

Source: own Illustration

A systematic combination of appropriate parameters of the different dimensions yielded relevant usage scenarios. The example marked in the chart shows a city scenario focusing on working people using the local public transport and significantly resorting to the surrounding infrastructure. It mainly aims at more quality of life. The scenario was developed as part of the usage scenario "New flexibility in public transport".

5 RECOMMENDATIONS

In order to implement the *New autoMobility* we need to actively design both the actual vehicle technologies and the technological surrounding. In the digital age value chains are changing at a breathtaking pace. The trend towards automation is accompanied by increasing social connectivity. It is up to Germany with its worldwide leading mobility industry of systemic importance to seize these opportunities. The *New autoMobility* cannot be realised without the cooperation of manufacturers, suppliers, research institutions and the political echelons. Only if we actively shape future developments and channel mobility solutions with regard to our social values can we meet these challenges. The following chapter contains a schematic description of the necessary measures. More precisely, we will here list prerequisites for the technical realisation and market launch of automated and driverless vehicles. As a next step, fundamental questions regarding the social impacts will have to be addressed. This will be part of the more extensive acatech study to be published in 2016.

5.1 MERGING AUTOMATION, CONNECTIVITY AND INFRASTRUCTURE INTO A COMPREHENSIVE APPROACH

Creating connectivity between vehicles and the infrastructure as well as merging traffic management systems and cloud-based services into an integrated approach significantly increase the merits of pure automation. Thus, particularly comfort and traffic flow can be further improved. In addition to technical developments, uniform standards for communication and cooperative decision-making between traffic participants must be established. Moreover, an early upgrading of the traffic information and communication infrastructure is required.

The current and future developments in the automotive sector towards automated and driverless vehicles will increase mobility, road safety and the energy efficiency of the various transport modes and enhance individual comforts. The functionality of sensor-based automation in vehicle control can still be significantly improved. Important steps include establishing connectivity between traffic participants, realising cloud-based analyses of the data involved, using high-resolution map information and merging these systems with traffic information and communication infrastructures. Safety, traffic management and user-friendliness are thus greatly enhanced. The usage scenario "Extra time" presents examples for the advantages automated road traffic offers to professional commuters in terms of time and comfort.

Connectivity between the traffic participants broadens the data basis to which every individual participant can resort. This enables better decisions in the dynamic driving task and enhances the robustness of the control systems. Thus, we can increase safety, not only for the passengers, but also for other traffic participants, such as a child playing in the street (cf. usage scenario 1B). The merging of vehicle automation with traffic information and communication infrastructure (TICI) that respond individually to specific situations likewise broadens the information base available to the individual traffic participants. Such appliances could be traffic management systems, e.g. traffic light controllers. In addition, such a merger allows for the flexible adjustment of the traffic environment, for instance by means of modifiable speed limits or traffic light control systems.

The realisation of a fully fledged driverless transport (corresponding to level 5, Figure 1) requires an early technical upgrading of municipal transport systems, e.g. road markings, traffic lights and traffic management systems, including the necessary data connections. This implies considering the existing degree of connectivity between vehicles as well as the nature of the information they exchange. In order to keep older traffic control machines in operation, we must ensure the downward compatibility of new systems. Only thus can we actually realise the potential for added value the combination of automation, connectivity and infrastructure offers. An appropriate regulatory framework must be developed to determine a set of guidelines for the implementation at the Federal and European levels. It is up to the manufacturers to develop and implement according standards for connectivity, communication and cooperative decision-making between vehicles. A second but related challenge is the establishment of according standards and norms for the communication between vehicles and the transport infrastructure. A networked transport infrastructure with all its advantages can only be realised if stakeholders from all sectors (manufacturers, suppliers, research institutions, associations, etc.) work together.

5.2 INCREMENTAL EVOLUTION TOWARDS AUTOMATED TRAFFIC

The establishment of automated road traffic requires a phased development plan including scenarios showing possible effects of an introduction of mixed traffic. We further need carefully planned incentives to effectively control and steer transport demand.

The establishment of automated vehicles requires a phased development plan. In all phases of the automation it is essential that this plan contains adequate regulations for the parallel operation of automated and conventional vehicles in a mixed traffic situation. These particularly include additions and amendments to the road traffic provisions and the designation of circulation areas. In order to optimise functionality, a selection of additional construction measures would be desirable. Road markings allowing automated vehicles a more precise localisation, for instance, would facilitate the cooperation of automated and conventionally controlled vehicles. The final stage of automation, completely driverless driving, can only be achieved gradually with an infrastructure enabling a mixed traffic of automated and driverless vehicles. The usage scenario "Extra time" indicates features that vehicles will require in differently developed regions (urban/rural), while the usage scenario "New flexibility in public transport" emphasises the social merits of a driverless transport infrastructure with regard to public passenger and freight transport in rural as well as urban areas. The combination of automated traffic and new offers by public or semi-public transport companies will eventually incentivise a choice of transport modes that will reduce the amount of traffic in city areas. Urban areas can then be recovered for other purposes. This opens up new prospects for urban design. An important tool in the context of a sensible demand-management system is parking space management, determining both the costs of residential parking and the parking charges for city visitors.

Developing a model that includes both the gradual creation and management of incentives with regard to transport demand is a task that requires the joint efforts of municipal representatives, mobility researchers and the industry.

5.3 ESTABLISHMENT OF LIVING LABS

The development, testing and evaluation of automated road traffic integrating both the various means of transportation and the traffic participants requires duly equipped Living Labs and test centres.

In the last few years, Living Labs have become an established tool for practically-orientated research into new technologies. Conceived as showcases and frequently operated as public-private partnerships, Living Labs offer experimental environments at the interface between technology, market and society. They assemble users, developers and planners at an early stage of a development process, creating a space for fruitful exchange and cooperation. Along with the improvement of technical development processes, the Living Labs focus on issues of public acceptance. For instance, in order to enable senior citizens better access to mobility (as described in usage scenario 3 B), they must be included in the design of mobility services. A Living Lab offers realistic and relevant surroundings where variations of automated traffic can be tested in different steps – from virtual simulations to mixed environments with real and virtual elements, tests in trial areas and finally test scenarios in semi-public and public spaces. The various modes of transport and the traffic participants (such as pedestrians, cyclists, buses, trains, trucks and cars) as well as their respective interactions must be incorporated ex ante in the surroundings of such a trial area. Hence, a Living Lab must include both a test site equipped with the necessary technical devices and a larger testing area. Along with central technical aspects like functional safety and the experimental detection of error margins, the assessment of customer benefits is a key aspect in the design of the Living Labs. They are further responsible for the development of adequate methods and standards to prove and validate functional safety. Such standards are not least necessary with view to the certifications required at later stages of the process.

The construction of national Living Labs conceived as large-scale research facilities and integrated into a network of international partners is an imperative step on the road towards a future world of automated road traffic. Investments are required for the large-scale testing of automated vehicles which will include active user participation. Also, legal certainty must be created. The pivotal point, however, will be to close the gap between research and marketable business models. To this end, possible business models should be evaluated as to their chances of implementation as early as possible, ideally in the conception phase of a Living Lab.

5.4 DEVELOPMENT AND INTRODUCTION OF STANDARD PRINCIPLES FOR HUMAN-MACHINE INTERACTIONS IN THE AUTOMOTIVE SECTOR

German producers, research institutes, auditing organisations and federal authorities should play a leading role in the development and establishment of international standards for security-related human-machine interaction in the automotive sector.

Automated vehicles will likely continue to require the driver for controlling central technical functions. This occurs in matters like route planning or the choice of a specific level of automation. For safety reasons, the basic principle behind the necessary interaction features should be comparable in vehicles of different types and brands. This includes standardising the interaction principles (analogous to the common principle of using the turn signals when changing lanes). It must particularly be ensured that the driver is at all times aware of the current level of automation and the respective (remaining) driving tasks it involves and can consciously carry out and comprehend any change in the level of automation. The usage scenario "Extra time" explains how the transition of the vehicle control from the system to the driver might be organised. Inadequate engineering and design could indeed result in serious misjudgments and thus jeopardise functional safety. Moreover, it remains important to avoid cognitive overstraining by too many or inadequately designed information channels in the car. This could affect the driver's attention on the surrounding traffic. Legal regulations of interaction principles in automated vehicles may be required.

The standardisation should also encompass the central terminology of human-machine interactions, like e.g. clear definitions of the various levels of automation. Such standardisations are necessary not only for the technical development process, but also to rule out any ambiguities in the interpretation of the information the vehicle system provides.

Standardised control functions are also vital for vehicle-to-infrastructure communication and for the interaction between road users. In other words, all traffic participants must be able to reliably anticipate the reactions of an automated vehicle. Therefore, functions affecting the safety of others, such as the automatic distance control, must be similarly designed, independent of vehicle type or brand. This includes signals to third parties, for example the signal indicating a vehicle's current automation level. More than any other European country, Germany, with its multitude of manufacturers and suppliers, has the know-how to push the development of safety-related features of human-machine interaction in the automotive sector. At the same time, German manufacturers are particularly affected by the necessary standardisation requirements. Therefore Germany should seize the opportunity to expedite the development of consistent interaction principles and to assume a leading role in the establishment of international standards for human-machine interaction in the automotive sector, involving European partners into the process at an early stage.

5.5 DATA PROCESSING FOR AUTOMATION AND CONNECTIVITY

Automation and connectivity depend essentially on the collection and processing of data and information from various sources. Here, we will have to develop models of data usage allowing all persons or institutions involved to resort to attractive and successful business models while respecting the personal interests of the users. Suitable framework conditions should facilitate interoperability between platforms.

Connectivity with other road users and with the traffic information and communication infrastructure significantly increases the functionality of automated vehicle control. The usage scenario "Safely on the road on foot and by bike" illustrates how safety improves for all traffic participants. In addition, new business models, e.g. for automated transport services as described in the usage scenario "Improved supply", exploit the potential of such data analysis.

In both cases, the quality of the data is paramount, especially their reliability and availability. The crucial point in dealing with data will in most cases be to determine who has the right of use. Hence, adjusting the systems to the requirements of data protection and data security will be a key field of action. According legislation is required, at least to coordinate the framework conditions. Possibly, the allocation of frequencies for the various telematic solutions which connectivity of automated road transport entails is a further issue to be settled by the regulatory authorities.

Given the important role of transport-related data for basic public services, both equal access for competitors and interoperability must be ensured. Especially regarding business models in the field of the net economy, the implementation of interoperability should be closely surveyed. It is crucial, for instance, that digital platforms from different suppliers are compatible in terms of roaming and data interfaces and collaborate accordingly.

Ensuring transparency in data collection and processing as well as the users' control over their personal data will be important criteria when it comes to gaining public acceptance for connected automation. Data traffic will have to be sufficiently anonymised. Here, a balance must be found between the various interests of the stakeholders and the expected benefits, e.g. the enhancement of road safety.

5.6 ACTIVE DEVELOPMENT OF THE LEGAL FRAMEWORK

In order to pave the way for successful market launches in the field of automated road traffic, regulatory decisions are required at the national and international level. The basic question in this context is how the legal framework must evolve to best ensure the necessary legal security for the development of automated road traffic.

Reliably developing the central technologies necessary for automated road traffic into commercially viable products entails comprehensive innovation processes with many iterations. Hence, unlike the issue of data protection, the evolution of the national and international legal framework is more than a matter of legal necessity. It is, indeed, just as imperative from an economic point of view, for instance with regard to liability issues arising from automation. If automated and driverless vehicles are to be integrated into the normal traffic, it is crucial to expedite current activities and developments such as the amendments to the Vienna Convention on Road Traffic (co-initiated by Germany) and the efforts of the Working Group Road Safety of the United Nations Economic Commission for Europe.

Further, a uniform international framework is due, in order to exclude e.g. trade and usage barriers. Data-intensive innovative business models for automated driving systems forcefully illustrate that in current legal understanding, data does not yet play the major role it will doubtlessly assume some years from now. The legislator faces a double challenge: On the one hand he has to ensure that the creation of innovative models is not impeded or altogether prevented at an early stage, on the other hand, he is called upon to provide the necessary legal security. This implies developing regulations that effectively protect the legal interests and reconcile the rights of all parties concerned.

On a more basic level, it must be decided how to generally approach matters in the legal and regulatory line. For instance, in how far is it necessary to modify existing legislation with regard to new facts and circumstances? Do some cases suggest the creation of new legislation, at least at the European level? Or can the new circumstances be subsumed under existing regulations? Another general question that remains to be answered is whether informal dialogues and voluntary commitments (co-regulation) could be an adequate instrument for the regulatory monitoring of research and development or whether an early-defined legal framework providing reliable legal security is altogether the better option.

A reasonable balance between socio-economic interests and possible technological risks should here be an essential criterion. Technological research must be flanked by adequate discussions and assessments of social and ethical issues, ensuring their consideration in the implementation of the respective stages of automation.

5.7 LAUNCHING AN INNOVATION PROGRAMME FOR THE AUTOMATED ROAD TRAFFIC OF THE FUTURE

In times of increasingly automated road traffic, keeping up the control and influence in questions of technological innovations requires investments in innovative research and development. A focal point should be to foster interdisciplinary research networks between universities, research institutions and companies by establishing coordinated support programmes.

Maintaining and further expanding Germany's leadership in the field of automotive technology, not least with view to an increasingly automated road traffic, requires massive technological developments. This reaches beyond the evolution of components such as sensors, situative interpretation, human-machine interaction tools or smarter, more resilient control algorithms. Higher levels of automation require more complex functionalities in robotics, cognition and connectivity between a networked automation system and the transport infrastructures.

In addition to technical issues, innovation is also required in the accompanying socio-scientific research, including technology assessment and acceptance research, as well as with view to the development of an appropriate legal framework. The evolution towards automated road traffic should be flanked by adequate science communication and a civil dialogue process.

A strong German position on the automated road transport market is not only desirable from an economic point of view, but also vital for the competitiveness of the automotive industry. Owing to Big Data, new business models are possible. Players originally from other industry sectors, such as the US-giants Google and Apple or Baidu from China are now competing with traditional producers in the manufacturing industry. Currently, these new global players have a competitive advantage in terms of information networking and distribution. They already have large amounts of user-generated data at their disposal. Moreover, global actors increasingly penetrate into the field of infrastructural services such as search engines or communication services, where they operate more or less beyond public control. In times of increasingly automated road traffic, a combined effort of all social players is required to keep up the control and influence in questions of technological design and avoid being forced back into the role of mere suppliers.

Past experiences have repeatedly proved the research and business measures with their focus on thematic clusters to be an appropriate tool to promote networking in business and research as well as between manufacturers, suppliers and small and medium sized companies. For the necessary knowledge transfer from basic and applied research, the cooperation of universities, research institutions and the industry is likewise important. The creation of such a network is the order of the day, particularly with view to the integration of technical, social and legal innovations which automated traffic calls for. Incidentally, funding programmes have frequently stepped in at an early development stage of an industrial sector; thus supported, numerous company clusters have obtained the critical mass necessary for long-term success in the market. The amount of innovations and alterations to which automated road traffic gives rise suggests that we will be facing the fundamental reorganisation of the entire automotive sector. It can consequently be assumed that in the current early development stage of automated road transport, funding programmes constitute an effective instrument of economic policy.

5.8 NEXT STEPS

The target scenario developed in this paper constitutes the foundation for the work of the acatech project group *New autoMobility* in the second phase of the project. This will be devoted to the development of a roadmap towards automated road traffic which will be published in an acatech study. The roadmap will develop the fields of action addressed in the present paper into specific policy recommendation, seeking to define the individual steps towards the realisation of automated road traffic up to the year 2030. While automated driving will remain a focal point, the study will take more account of relevant cross-cutting issues.

The increasing maturity of automated vehicle functions and of the underlying infrastructure also heightens the need to find answers and solutions to overarching questions regarding the social impacts of new vehicle technologies. These include:

How can we ensure operational reliability even under exceptional circumstances? How can we protect connected and automated vehicles against attacks? How can data protection be guaranteed with respect to safety-related monitoring? What standards and certifications are necessary to establish uniform IT-security concepts? What are the basic principles we need to establish to ensure a common understanding of human-machine interaction? How can automated road transport be fitted into our existing transport system in urban or rural surroundings? Will automation affect the organisation of work and employment in the mobility sector? What form of public debate on fundamental ethical issues is required? What measures are necessary to involve users and the public in the design of a future transport system?

These issues highlight the far-reaching importance of mobility as a key component of our society. Some of them will be taken up and discussed more closely in the further work of the project, although the broadness of the topic makes the consideration of all aspects impossible.

The results of the second phase of the project are to be published in an acatech STUDY towards the end of 2016.

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Owing to developments in the field of assistance systems and automated driving, vehicles are taking over more and more elements of the driving tasks hitherto incumbent on the driver. Thus, automation and connectivity are under way of revolutionising the road transport system. In the present POSITION paper, the project group New autoMobility, a joint initiative by the Federal Ministry of Transport and Digital Infrastructure and acatech, develops a target scenario of a world of automated road traffic in a future beyond 2030. It provides a set of usage scenarios addressing the challenges of our present mobility system. On the basis of these scenarios, the project group worked out specific policy recommendations for implementation in politics and society. They describe what steps must be taken to set the course towards automated road traffic and how best to take advantage of its ecological, economic and social benefits to promote public welfare.