AUTONOMOUS DRIVING

AND THE DIGITAL TRANSFORMATION OF THE AUTOMOTIVE INDUSTRY - THE CRUCIAL ASPECTS.
Mobility is a mega-trend resulting, above all, from progressing urbanization, demographic change and the flexibilization of professional and private life. Especially in urban regions and particularly in metropolitan areas, mobility keeps growing significantly – even though transport infrastructures are limited, environmental problems are increasing (CO₂, NOₓ, noise) and the number of accidents and casualties is beyond socially acceptance.

A gradual introduction of conditionally automated and highly automated (Levels 3 and 4) as well as driverless, fully autonomous vehicles (Level 5) is expected to provide the technical solution to the requirements and problems of growing mobility. By implementing this vision, these vehicles enable new business models (e.g. ride hailing, last mile deliveries) and give over-the-top providers the opportunity to use the now available travel time to market their services (e.g. entertainment, shopping, food).

From around 2020/2021, the commercial use of autonomous vehicles is to be expected in defined urban areas, and from around 2025 also in extended urban regions. This will yield a major transformation in the automotive value chain – especially in customer management, after-sales and retail processes. For example, driverless mobility services (MaaS) focus on fleets that are increasingly making vehicle ownership obsolete in urban regions. New MaaS providers are therefore establishing themselves in customer relationship management between end customers and product providers (OEM, after-market). Besides the risk of disruption, there are also opportunities for the traditional automotive ecosystems in the form of own mobility services, fleet management i.e. service business for fleets, and the placement of over-the-top content and services.

Currently, R&D projects of many OEMs and Tier 1 suppliers focus on the development and validation of autonomous vehicles, combined with the transformation to electromobility. The integration of new vehicle technologies as well as the real and virtual validation of vehicles for road traffic come with highest priority.
Challenges

Technologies
Increasing automaton makes further sensors and the fusion of their data necessary in the vehicle. While cameras, front radar and ultrasonic sensors are sufficient for Level 2 driving situations, Lidar laser scanners are indispensable at Level 3, along with additional camera and laser systems in order to obtain a 3D image of the surroundings in real time. At Level 4, the number of sensors for a complete all-round view will again increase significantly.

In order to process the huge amount of sensor data, the vehicle must be equipped with a high-performance data-bus system. The sensor fusion generates a current and accurate image of the environment, but requires high-performance central processors in the vehicle that have a high energy demand and need active cooling. In the R&D phase, the processed and collected information must be stored several times a day for analysis. In serial application, online exchange of sensor data with a driver assistance backend takes place, which also includes data from other vehicles and sensors of the traffic infrastructure. This allows the generation of a high-definition map of the traffic situation.

Data
Autonomous vehicles generate enormous amounts of data, depending on the type and accuracy of the sensor, which are exchanged with a driver assistance backend when processed. Apart from the derivation of a driving strategy, the data is also used to learn new or changed traffic and driving situations. This learning process is largely implemented with machine learning methods (artificial intelligence) and takes place throughout the entire life cycle of the autonomous vehicle.

While in the R&D phase simulations generate a significant part of the data, the serial phase mainly provides real information. Both call for high demands on the IT infrastructure in terms of capacity and performance. Further challenges are the verification and validation of data algorithms and the protection of personal data.

Automotive Processes
R&D processes for developing and validating autonomous vehicles must be agile. They are characterized both by complex sensor technology and, in particular, by the growing importance of software-derived algorithms and collected data. The vehicle backend is no longer only used for optional telematics and remote functions as today’s connected car backends. Instead, the autonomous vehicle must be an integral part of the backend for driver assistance functions. The challenge is to ensure functional safety, end-to-end from the vehicle to the backend. Another change concerns the R&D working method: Cooperation with IT companies and digital platforms is no longer restricted exclusively to sequential and static supply chains, but also takes place in permanently changing value-added networks.

In order to optimize the last mile of transport in vehicle production in the supply chain, the first autonomous applications are already being piloted in parallel. Here, the integration of process and plant infrastructure must be addressed.

The availability of fully autonomous vehicles (e.g. robos-axi) shifts the need for change to aftersales and retail processes. Mobility services (Maas) will focus on fleets and make vehicle ownership in urban regions increasingly obsolete. In addition to the disruption of customer relation management, new business opportunities are emerging, such as maintenance and services for robo-taxi fleets and over-the-top business models for the production of content and services for reusing the driver’s freed-up time.

As a result of the transition from product business to service business, traditional control instruments and KPIs used in the finance process no longer meet the requirements of new business models. For this reason, models for the simultaneous control of classic and digital business models are gaining more relevance.

Processes of Human Resource Management must follow the agile working method in projects and networks. The iterative and dynamic approach, cooperation with global digital platform providers in the vehicle, a massive expansion of the supplier base (incl. startups) as well as the organization in networks will be reflected in changed cooperation, communication and management processes, through to skill development for staff and executives.
Innovation drivers in autonomous vehicles are often start-ups that either focus on comprehensive full-stack solutions (software and hardware from a single source) and require enormous financial and strategic resources or that specialize in other specific niches in order to assert themselves in the market. Start-ups with a strategic orientation towards OEMs want to position these key technologies along the value chain.

**Full-stack Start-ups**

At 250 billion US dollars, WAYMO is valued higher than Ford, GM, Fiat-Chrysler, Honda and Tesla put together. The Google spin-off develops a full-stack solution for autonomous driving, consisting of both software and hardware. It has set itself the goal of developing a new type of mobility and road safety with self-driving vehicles. After several years of testing, the autonomous taxi service WAYMO One has been the first commercial beta test operating in an ideal city (Phoenix/Arizona) since the end of 2018. Experts currently rate WAYMO’s technological lead over its competitors as “miles away”.

While WAYMO emerged from an internal Google project, the start-up AURORA was founded in 2017 by former UBER, Tesla and Google employees who are considered luminaries of the robot-car scene. With its solution comprising sensor technology, software and data services, AURORA aims at Level 4 and 5 of autonomous driving. According to various sources, the start-up has already rejected several takeover bids, including those from the VW Group. Instead, it secured the strategic support of Amazon and Sequoia Capital (investor in Yahoo, PayPal, Electronic Arts, YouTube, Apple, WhatsApp, Instagram and Google, among others) with a €467 million financing round.

**Start-ups Focusing on Key Technologies**

Chinese start-up MOMENTA AI, founded in 2016, is a Tier 2 software provider and describes its solution as the “brain” of the vehicle. The deep learning software enables object recognition, semantic HD live mapping and data-driven route planning. In October 2018, the start-up secured a US$1 billion investment, making it China’s first “autonomous unicorn”.

BRODMANN17 is a deep learning start-up from Israel that raised US$11 million in a Series A financing round led by OurCrowd in March 2019. The round also included Maniv Mobility, Al Aliance, UL Ventures, Samsung NEXT and the Sony Innovation Fund. BRODMANN17 has special expertise in algorithms for training neural networks. On this basis, the company has developed a lean computer vision technology that also runs on small, low-end processors in cars and can complement lidars, cameras and radar sensors. The start-up is currently integrating its technology into a car manufacturer’s front and rear-view cameras in order to better identify objects during journeys maneuvered by humans.

Vehicle data is a key factor for autonomous driving and innovative mobility services based on it. To this end, OTONOMO is developing a networked vehicle data marketplace that enables automobile manufacturers, mobility service providers and application developers to securely exchange and integrate vehicle-generated data. The aim is to make the driving experience safe, smart and comfortable. The start-up has already established an ecosystem comprising more than 75 partners, including, according to a Bloomberg report, ten automobile manufacturers that provide, market or otherwise use data – including Daimler, in whose Startup Autobahn accelerator program OTONOMO participated in 2016.

**Cooperation between Start-ups and OEM/Tier 1**

Strategic alliances with the best complementary start-ups can enable OEMs and Tier 1 companies to catch up with WAYMO and other – provided they effectively orchestrate partnerships and rapidly integrate the necessary technological building blocks into their overall solutions. Leading start-ups in key autonomous driving technologies are surrounded by potential partners early on, as time, talent and technology expertise are crucial. The failed attempt by VW to acquire AURORA clearly shows that emerging start-ups in the autonomous driving sector have enough self-confidence, resources and expertise to choose the type of strategic cooperation (investment, acquisition, co-development, etc.) and partners according to their needs. In order to secure alliances with the best partners from an OEM and Tier 1 perspective, it therefore requires a group-wide, strategic collaboration process.
Research & Development

Unlike the previous approaches to software development for driver assistance systems, which are able to achieve a level of automation in limited scenarios, a different holistic approach must be adopted to achieve autonomous driving. The radical change is tantamount to a paradigm shift.

Irrespective of a possible request from the vehicle to the driver to take back control (Level 3 and 4), these vehicles must be able to handle a wide variety of different and even unknown driving situations confidently in order to ensure smooth driving behavior. Such a large quantity of potential scenarios, however, cannot be achieved by deterministic algorithmic and software development, since the number of algorithms and driving functions to be developed and of the necessary software developers and testers required for this strives towards infinity.

The only realistic approach is therefore to analyze as many recordable and generated virtual driving scenarios as possible using automatic approaches and to derive a precise trajectory and driving behavior planning of the vehicle with non-deterministic approaches. Since traffic and the resulting driving scenarios are constantly changing, it is necessary to pursue a closed-loop development approach, with which the vehicle’s behavioral models are continuously further developed and delivered models are updated on the basis of real driving data. This requires a radical rethink from fully completed projects to development projects with release and integration stages and no time limits.

For data generation it is indispensable to equip the vehicles with suitable sensors. Safe maneuvering requires that they are able to provide data in all conceivable scenarios in order to capture the immediate vehicle environment with a high level of detail.

The resulting amount of data is extremely large (many petabytes to exabytes) and can only be stored and processed by suitable IT systems (see Data Management). However, manufacturers often do not have such IT infrastructures at their disposal today or do not have them available in a sufficient expansion stage.

The data provides the basis for learning driving behavior models, which are trained using a suitable machine learning approach (e.g. deep learning). Only high data volume allows reliable and stable models to be learned that guarantee both safety and a convenient driving experience. In order to accomplish this paradigm shift as smoothly and quickly as possible, it is also necessary to employ data scientists and machine learning experts.

Supply Chain

Autonomous transport vehicles enable the supply chain to be optimized. In addition to the use of autonomous trucks for JIS/JIS delivery (just in time / just in sequence), the focus will be on automated in-plant transportation. An early application scenario is the last mile on factory premises.

In the supply chain, drivers are regarded as a significant cost factor, associated with numerous requirements for driving times and rest periods. Furthermore, the demand for qualified truck drivers remains very high in major industrial nations, thus causing bottlenecks in terms of the availability of professionals. This is where concepts for (semi-)automated truck transports could provide a solution.

With conventional delivery concepts, the truck has to wait at the reception of the plant until admission is authorized and then cover the “last mile” to the assigned unloading gate or bay. There the truck and the driver have to wait again until unloading or loading is completed. The truck then drives a few miles back to the exit point of the factory premises. Automated trailer transport with swap bodies is the ideal approach for this time-consuming process covering a very short distance. Truck drivers park their trailers at the reception in a special transfer car park and pick up a loaded or already empty trailer in this parking area. The turnaround time takes only a few minutes and the scarce resource of truck drivers is used with much greater efficiency in a driving area that is particularly difficult to automate: public roads and, in particular, motorways.

In-plant transport at usually very low speeds, on the other hand, is carried out fully autonomously. Various research projects are currently analyzing the technical application possibilities for the use of autonomous trucks on plant premises: SCHENKER is testing this concept in Sweden with the FFpod from its hardware partner ENEIDE. Recently, the Swedish government even approved the concept for driving on some public roads. The GÖTTING Compapa has been establishing two autonomous 40-ton trucks in a Berlin production plant for several years to connect two production halls. Since the opening of a new tank container storage facility in 2018, BASF has introduced series operation for the automated transport of tank containers at its Ludwigshafen site. In the joint project AutoTruck of the Fraunhofer IVI from Dresden, the conversion of an electric truck for automated driving on the factory premises is currently being carried out together with partners.

It becomes clear that in this environment some market participants are currently testing different applications, partly with productive use. In our opinion, the number of productive applications will continue to increase over the next 6-12 months.

We are currently observing massive efforts in the automation of outboard processes, partly carried out in the automotive sector, which can be divided into two different streams: a group of companies tries to either have the finished vehicle automatically drive to a parking lot within the plant by existing onboard electronics including the sensors, or to automate the trip to the nearest parking lot on the plant premises by attaching additional modules to the vehicle control system and removing them again upon arrival.

The second group includes projects such as the Ray parking robot from Serve TS or the parking robot from Stanley Robotics, which is currently in the pilot phase at Lyon Airport. With these systems, the finished vehicle is lifted up by the parking robot (a kind of AGV) and placed on the assigned parking space. AGV systems are used as sensors and electronics for the automated trip, making interventions in the automobile’s vehicle systems unnecessary.

Future Retail

Autonomous vehicles will force automotive retail and service concepts to change in the upcoming years, it will be necessary to innovate has led to disruptive changes, which, in turn, offer opportunities for sustainable growth.

A specialization of retail businesses is to be expected. In addition to classic companies with vehicle owners (Level 3 and 4) as target groups and specific target marketing, new and highly automated companies will focus on Level 5 vehicles in MaaS business models. For this purpose, the CFO therefore (s) of the car manufacturer has a key role to play in shaping the future of the company. The CFO’s field of activity includes, in particular, the development and management of new mobility concepts. He has to master the balancing act of efficiently managing the existing portfolio and adequately promoting the development of innovative mobility solutions. Central professional requirements are agility, decision orientation, foresight, cost efficiency and the compliance with legal and regulatory requirements. For the development and introduction of disruptive digital concepts, companies usually invest two to three-digit million amounts per year. CFOs are increasingly criticized both the transparency of the expected value contribution and the comparability of individual measures. For the financial sector, this already means that the future value contribution of ideas and emerging mobility concepts must be continuously reflected upon today. New mobility concepts as synonyms for the products and services of the future also entail management challenges. Classical management tools and KPIs no longer meet the requirements of new business models and do not adequately reflect the “true value” of digital initiatives. A model for the simultaneous management of classic and digital business

Next Finance

For many decades, the product was the central element of the automotive chain. In the upcoming years, it will become evident that the automobile is no longer merely a means of transportation, but rather a platform for mobile communication. Connected cars are outside the car manufacturer and are managed by companies to automate their workshops, in combination with a mobile app. The range of different applications can be divided into two categories: a group of companies tries to either have the finished vehicle automatically drive to a parking lot within the plant by existing onboard electronics including the sensors, or to automate the trip to the nearest parking lot on the plant premises by attaching additional modules to the vehicle control system and removing them again upon arrival.

Another application scenario in retail is support services for MaaS fleets such as cleaning and, if necessary, preparation of fleet vehicles, local roadside assistance and tele-operation. If a robot is in an unattended traffic situation (e.g. the passage of other road users when double parking where the center line is continuous or when blocking a one-way street) or if a breakdown occurs, a teleoperator has to intervene. The operator has access to the vehicle sensors and remotely controls the vehicle in a defined autonomous driving situation.

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models will become increasingly relevant both for OEMs and globally active suppliers in the next few years. In addition, it is necessary to build up competence in risk management and compliance in order to be able to meet legal and regulatory requirements with foresight and not have to react with massive short-term efforts on a regular basis.

A roadmap that is aligned to a target and encompasses individual measures can serve as a central approach to bring transparency to the multitude of ongoing initiatives, to weigh up opportunities and to close gaps in the target image. Industry-specific benchmarks can be used, in particular, in the development of holistic digitalization programs and their continuous updating. In order not to run the risk of misjudging the potential of digital investments and to remove them from the portfolio before they reach market maturity on the basis of classic key figures, it is necessary to develop a visionary management concept. On this basis, classic and digital business models can be adjusted seamlessly.

Organization & Management

In addition to further complex technologies such as sensors and software, and the massively growing importance of data, the development of autonomous vehicles will also require internal teams and supplier networks to work differently. Teamwork, communication and leadership processes must change – towards agile project work, iterative integration of virtual security with physical testing, collaboration with global digital platform providers directly in the vehicle, a massively expanded supplier base (including start-ups) and organization in networks. This will have a strong impact on the short-term development resp. selection of skills of employees and managers.

In a more diverse working world, new managers must be able to establish order even in unstable structures, remove obstacles to performance, ensure employee motivation and productivity, and open up and develop implicit organizational knowledge. The organization of the interplay and the orchestration of diversity become a central leadership competence. The aim is to create many attractive project and specialist career options as an alternative to few classic management career options.

The transformation of OEMs from product providers (mobility enablers) to service providers (mobility providers) requires further changes in personnel and in the culture and organization (e.g. project organization instead of organizational structure, product owners instead of Taylorism). The work of the future will require frequent change from everyone. The willingness and ability for change – of structures, processes, competencies – make companies and individuals resilient in a world that is changing rapidly and more frequently in an unpredictable way. The question of the capacity and competence of organizations and employees must in any case become a central component of all digitalized organizations. While innovation development, for example, is often institutionally “outsourced” to the R&D department, the success of crowdfunding and open source platforms proves that innovations thrive best when they mature from the center of society or from the “non-carpeted” levels of the organization.

While the private garage is recognized in the USA as a haven of inventiveness and start-up culture, it is still used much more effectively in Germany. In such an environment, it is more than necessary to strategically determine the innovative ability of the organization and its employees. Capability-oriented organizational development can be the key to making the innovation capability but also the learning ability of an organization visible.


Essential Technologies

Data Management

To enable a vehicle to act independently and confidently in all conceivable traffic situations, a sufficiently complete set of data is required as the backbone of driving behavior models. This data is obtained from the environment perception sensors (e.g. camera, radar, lidar) as well as from the chasis of the vehicle (e.g. speed, braking torque). The recording of these sensory outputs leads to enormous amounts of data, reaching the order of a few hundred petabyte up to the exabyte range.

This data must be transferred promptly to the IT data landscape to avoid significant loss of time during development. This requires bandwidths to the database systems with a high data transfer rate. An outlook into the future indicates an expansion of wireless networks with high data transfer rates.

An infrastructure of several hundred petabytes is required to ensure the storage and processability of this data. This should be configured in a way that distributable storage is permissible: On the one hand, it ensures that large data packages can be stored in a distributed manner, on the other hand, the scalability of the entire infrastructure is maintained. At the same time, a high system’s performance is crucial so that parallel high-speed data processing is possible. In view of the exponentially growing number of measurement data, importance should also be attached to the scalability of both the infrastructure and the computing platform.

Finally, data governance must be ensured: This means that the data must be both consistent and available at high speed at all times without compromising data security.

Machine Learning

In order to achieve social acceptance, extremely high expectations are placed on the driving behavior of an autonomous vehicle. This includes a safe control of the vehicle (for itself and other road users) in all conceivable traffic scenarios. These include, in particular, confusing traffic situations such as road works or dense urban traffic and also challenging weather situations. In particular, confusing traffic situations such as road works or dense urban traffic and also challenging weather situations. In particular, confusing traffic situations such as road works or dense urban traffic and also challenging weather situations.

1. The key for development of such an all-embracingly competent driving behavior are machine learning methods. A good approach for this is the training of neural networks, for example the deep neural network. Here, the neural network derives a driving model on the basis of the measurement data described above (it is “trained”); this model is refined through iteration and on the basis of each new data set.

2. The functioning of a deep neural network can be briefly described as follows: In order for these models to converge stably in the interests of the user, safety and driving experience, the network must be taught a concept of “right” and “wrong.” For this purpose, they are not only additionally supplied with traffic rules, but also trained in a driving style that a passenger considers pleasant, as described above. The neural network is set up in a way that it never tries to get “wrong” as feedback (e.g. by disregarding traffic rules, unsafe or unpleasant driving behavior). Every time the network gets the feedback to be “right”, this behavior is established more firmly in the driving models and thus reinforced, whereas a “wrong” is interpreted as punishment and leads to its avoidance.

3. To avoid unwanted driving styles being learned during this training, or inconsistencies in the environment detection arising from the sensor setup or failure, the sensor data must be consolidated and checked for integrity prior to model training. Object recognition and extraction based on sensor data (data fusion) can already be carried out here, so that raw data no longer have to be transferred to the neural network. The advantage is that a certain robustness against the sensor setup is guaranteed, since the neural network expects conformity at its input interfaces, which can be ensured via the intermediate step of data fusion.

4. Furthermore, the trained driving models can finally be checked for their performance. On the one hand, this can be fully implemented in the virtual world (“digital twin”). On the other hand, an integration into a test vehicle lends itself for which the difference between the performance that the driving model would yield compared to a real existing driver is determined (“shadow mode”). It is also conceivable that the driving model controls itself – under the strict observation of a present observer (respectively a fallback level as a driver), who interrupts the driving model and takes control in case of respectively poor behavior.

The feedback of the results of this performance analysis completes a closed-feedback loop development approach. Together with sufficient data availability, this is indispensable for training a deep neural network, for example.

End2End Security

Highly automated driving expands the vehicle’s potential through the use of numerous hardware and software components. Unfortunately, it will also increase the risk of cyber-attacks. The complex on-board network structure alone is a challenge for integrated security architecture – expanded sensor technology and increased data communication considerably enlarge the possible variety of attacks.

For highly autonomous vehicles, the attack vectors can be divided into four areas:

- vehicle sensor technology
- on-board electronic system
- telecommunications unit
- backend

Each of these components is co-responsible for the safety of an entire vehicle. Thus, an attack on individual vectors would call into question the overall safety of the vehicle. The risks are described below.

Vehicle Sensor Technology

The data recorded by the sensors are decisive for a vehicle’s detection of the environment; cameras, lidar, radar and ultrasound are physically installed in the vehicles and are partly easily accessible from the outside. An attack on the sensors falsify the recorded data and deliberately induce the vehicle to take the wrong action. The lack of authentication of the sensor components would allow a man-in-the-middle attack and would also introduce false data into the vehicle’s electronic system. Attacks are difficult to identify because the falsified data is legitimately included in the decision and the vehicle reacts correctly. If the sensor is fooled into recognizing a wall, the algorithm will slow down. Thus, the process is completely intact in itself – except for the error that there is no wall.

On-board Electronic System

Communication in the on-board electronic system is very extensive. Due to the large amount of data generated, denial-of-service attacks can quickly bring the systems into an undefined state. The on-board electronic system could be attacked, for example, by OBD interfaces, but also via infotainment and USB interfaces. In addition to unstructured denial-of-service attacks, it is also possible to deliberately import false data into the electronic system (e.g. CAN Broadcast).

Telecommunications Unit (TCU)

The telecommunications unit (TCU) is one of the sensitive interfaces. In the complex world of SIM / eSIM / WiFi / Bluetooth etc., considerable risks exist in standardized components. Manufacturers of complex modem functionalities can be reached from the outside without physical access. If the modem chip of a supplier has a known security gap and this modem is installed in a vehicle, this gap could be exploited and can be used as a door-opener to get access to other components inside the car. “Aging” of the hardware is a serious challenge for these components. While such components are replaced relatively quickly in smartphones and the products have a short lifetime, it can happen in vehicles that 15-year-old modem chips are no longer supplied with security updates, but still exist in a car.

Backend

The permanent communication between vehicles, infrastructure and backends allows the servers or components to be attacked outside the vehicles in order to inject malicious code directly into the vehicle via secured channels.

Further Options

In addition to the above-mentioned risks, attacks can also be made other than in vehicle technology. The actions of a highly autonomous vehicle are predictable. Since driving behavior is a result of algorithms, it is possible to predict how a vehicle will react in certain situations. Climb-the-hill attacks could be used to manipulate the environment to such an extent that the algorithm calculates the desired result and the vehicle deliberately
Autonomous driving changes the entire automotive process chain. In R&D, this can already be seen in the development and securing of highly and fully autonomous vehicles in cross-divisional project centers and collaborations. At the same time, the first validations for supply chain and retail processes are taking place with pilots for the optimization of “last mile” transports in the production sector and in workshop automation. The transformation of the business model from a mobility product to a mobility service also has a massive impact on the secondary processes of finance and human resource management, which have to find answers to changes with new management tools and agility.

The use of MaaS business models with fully autonomous vehicles from around 2020/2021 in the USA and China will significantly increase the transformation pressure on the automotive ecosystem with its traditional value creation processes. The preparation and management of these disruptive corporate changes with regard to markets, value chain, management tools and organization must already be started today.

About MHP

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