The influence of highly automated driving on the automotive industry

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***Abstract*— Autonomous vehicles are a key driver of the fundamental change that is going to happen in the automotive industry in the upcoming years. In less than one decade, vehicles are expected to be capable of driving autonomously, at least in certain use cases. According to our estimations, more than 9 million higher automated vehicles (able to drive autonomously in use cases) will be on the streets worldwide in 2030. This induces fundamental changes within the automotive industry. With an increasing degree of automation, the importance of certain customer requirements is growing, while other factors, like motorization and handling are expected to lose importance. New players will enter the automotive value chain specializing on both software and hardware solutions, which require specific capabilities and competencies.**

Besides the shift in the value chain, autonomously driving vehicles have the potential to fundamentally change the market for after-sales and services in the automotive industry. New business opportunities arise from highly automated cars, which enable the driver to delegate all responsibilities to the vehicle, if he is in the car at all. The driver will no longer be the pilot but a passenger or a potential customer respectively, in the view of multimedia companies. Similar to the value chain changes, new players will target this promising opportunity. In order to compete with new entrants to the industry, automotive players have to rethink their understanding of the customer and develop flexible approaches to target those business opportunities.

Keywords — Highly automated driving, autonomous driving, business opportunities, market estimation, value chain analysis, market analysis

I. INTRODUCTION

According our understanding, highly automated vehicles are expected to reach full introduction within the next years, while fully automated vehicles (autonomous vehicles) are at least two model cycles away. Since highly automated vehicles allow the driver to delegate the driving task to the car in certain use cases, (e.g. on highways), the driver is downgraded from pilot to passenger. This creates completely new business opportunities for both OEMs and new entrants to the automotive market. Autonomously driving vehicles provide the ideal chance for competitors from other industries, e.g. multimedia and telecommunication companies, to extend their business with current clients in an unexploited area. Besides this, some of those new entrants even consider to attack the most established OEM domain, the production of cars, and again some, such as Google Inc., are already working on it. These revolutionary changes will induce fundamental shifts in the traditional value chain and redirect the revenue streams within the automotive industry. In order to maintain their leading position in the market, automotive players have to own the megatrend "Autonomous Driving", its influences on the automotive industry and adapt their strategies accordingly.

II. GENERAL ASPECTS

General aspects of automated vehicles are introduced in the first chapter. For this purpose, the fundamental terms are defined first. Afterwards, drivers and barriers for highly automated/ autonomous vehicles are briefly discussed to understand industrial, governmental and public motivation concerning the topic and their particular involvement. Conclusively, an estimated introduction forecast is shown and compared with the current state of the industry.

A. Definition of automated and autonomous systems

Basically, automated systems are the advancement of assisted systems. While the latter have the purpose to facilitate driving and enable a more comfortable and/or safer driving experience, automated systems are able to provide more than this. These systems are characterized by a higher level of automation, which allows the driver to delegate certain tasks to the vehicle itself or the systems respectively.

Generally, there are several definitions to distinguish between the degrees of automation of assisted and automated systems. This paper will use the definition of the German Automotive Industry Association (VDA), which is illustrated in Table 1.

The association defines five levels for assistance systems, with different responsibility distribution between driver and system. The levels are characterized by a descending degree of responsibility of the driver and ranging from assisted to fully

TABLE 1. LEVELS OF AUTOMATION

Level	Name	Driver's responsibility
0	Driver only	All driving tasks
1	Assisted	Longitudinal **or** lateral dynamic driving task
2	Partial automation	Monitoring of system at all times
3	Conditional automation	Capability to resume driving tasks
4	High automation	Driver **not** required during defined use cases
5	Full automation	No driver required

automated systems, whereas a driver-lead car could be considered as "Level 0". Level 1 systems are assistance systems, like a Lane Keeping Assistant. The higher levels represent automated systems. The latest systems in use are considered to be partially automated (Level 2), since e.g. a highway assistant is able to perform both dynamic driving tasks (longitudinal and lateral), but has to be monitored by the driver at all times. However, overlaps in the classification of particular systems are inevitable since systems may be limited to a certain degree of automation, or degree of driver control respectively, due to legislative reasons.

B. *Key drivers and barriers for autonomous vehicles*

As mentioned above, many players have an interest in the introduction of highly automated vehicles. This leads to various key drivers and barriers. In the following some of the most important are listed:

1) *Drivers*

- *Safety*: Since ~90 % of accidents are induced by human failure, highly automated vehicles could reduce this risk and increase traffic safety significantly
- *Comfort*: Automated vehicles could increase the travelling comfort especially in rush hours or on long trips by overtaking tasks from the driver
- *Ecological issues*: Autonomous driving vehicles are operating more efficient and sustainable than human-driven vehicles. Furthermore, level 4 and 5 vehicles enable new eco-friendly mobility concepts, in which e.g. a car is optimized in order to serve a specific purpose.
- *OEM competitiveness*: OEMs could profit from the reputation to be "the first to introduce the next generation vehicle"
- *Other factors*: E.g. industrial requirements

2) *Barriers*

- *Public acceptance*: Customers have safety concerns when redirecting the driving task to a machine and are generally not willing to pay more for an automated car
- *Data management*: Further technological progress is needed, since highly automated systems generate about one gigabyte of data per minute. Therefore, an immense computer capacity is required for data processing and storage. Furthermore, a steep advancement in machine learning is necessary to enable autonomous driving
- *Legislation and administration:* The driver is downgraded from pilot to passenger, resulting in a situation where liability and legislation are not defined yet (compare Vienna Convention)
- *Other factors:* E.g. ethics, lack of infrastructure

These factors have great influence on the development and success of autonomously driving vehicles. There is still a lot of work to do in order to overcome the barriers, especially in terms of technology and legislation.

C. *Timeframe for the introduction of higher automated systems*

Considering these drivers and barriers, introduction time frames for the particular levels and the connected features were estimated by the VDA. These are illustrated in Fig.1, where the systems are further divided into parking and driving features, due to the different complexity levels of the according tasks.
The VDA has assumed an evolutionary product development process for the estimation like it is established in the automotive industry. This means, that e.g. a highway pilot is developed

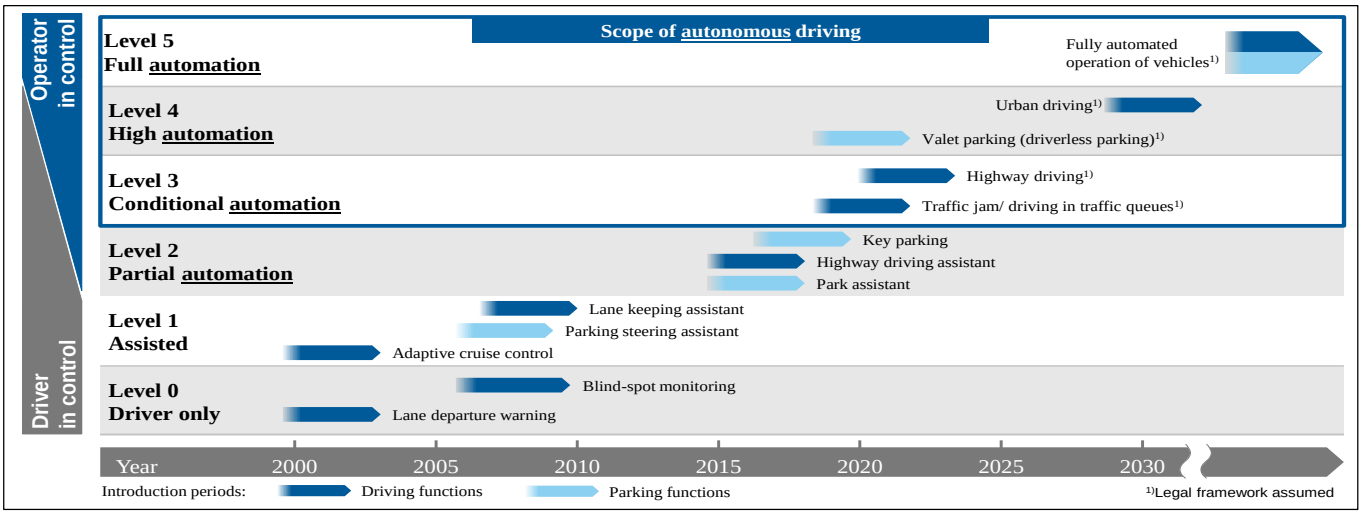

Fig.1 – Levels, features and timeline of automated driving and parking systems (based on VDA)

based on a highway assistant and therefore, it includes all its capabilities. First, the systems will be introduced in specific use cases, e.g. valet parking in automated parking areas, and after they proved their feasibility, they will be released for street use. This applies for higher automated systems up to level 4. Fully automated/autonomous vehicles could experience a disruptive introduction. Especially new entrants to the industry, like Google, intend to directly launch an autonomous vehicle.
This paper will mainly focus on higher automated vehicles (level 2 to 4) and their influence on the automotive industry.

D. State of the industry

Almost all OEMs are working on solutions to enable autonomous driving. There are only a few exceptions, which are mostly sports car and niche manufacturers. Nevertheless, views on the topic differ significantly between the OEMs. starting with the nomenclature, from automated to piloted driving, and ending at the announced years for the introduction of automated systems. Following the traditional development path, the degree of automation of the vehicles increases across the industry and will reach new heights with the entrance of several players from other industries. Besides Google, Uber, Apple (strongly assumed), Faraday Future and numerous start-ups are working on autonomous driving. These new competitors are putting further pressure on the established automotive players to promote the development of automated cars. Considering this, autonomous driving appears to become reality within the next decade, whereas fully automated vehicles are at least two product cycles away.

III. MARKET ESTIMATION

Based on this, Strategy Engineers developed a market estimation model to show the global penetration/installation rates of assisted and automated systems until 2030. In the following the model is briefly explained and the results are presented and discussed.

A. Brief explanation of model

The model is based on the particular feature prices and the customer's willingness to pay which differs by car segment. Simplified, it is assumed that a certain percentage of customers is willing to pay a certain maximum price for a feature. By combining this with the feature price in the according year, the take rates for this feature are determined. The feature prices underlie price decreases, which can be varied. By that, it can be included that certain system components, e.g. surrounding sensors, will become commodities. Furthermore, legislative incentives can be modelled by their influence on the customer's willingness to pay.
The model focuses on automated driving and parking features from level 2 to level 4, while fully automated are expected to be introduced after 2030. The model recognizes the following systems:

- *Driving:* Highway Assistant (partially automated), Traffic Assistant, Highway Pilot (both conditionally automated), Urban Pilot (highly automated)
- *Parking:* Parking Assist (partially), Key/Valet Parking (accounted to conditionally automated)

Generally, the features evolutionarily add to each other, which means that e.g. the Highway Pilot must provide the capabilities of the Highway Assistant and therefore replaces it. Further, the particular years of introduction of the systems were assumed according to Fig.1. Additionally, assumptions for the feature prices were made based on expert interviews and accordingly the customer's willingness to pay was distributed over the different car segment.
Based on these assumptions three scenarios were developed. These are further explained in the next chapter. The specifications for parking and driving features in the different scenarios are shown in Table 2.

TABLE 2. YEARS OF FEATURE INTRODUCTION

Feature	Scenario		
	Low	Base	Progressive
Driving			
Level 1 features	Not in scope		
Highway Assistant	Introduced	Introduced	Introduced
Traffic Assistant	2025	2022	2019
Highway Pilot	2028	2025	2022
Urban Pilot	2030	2028	2025
Parking			
Parking Assist	Introduced	Introduced	Introduced
Key/ Valet Parking	2025	2022	2019

B. Results

Based on this, the market for automated driving systems was estimated. In the following, the assumptions for the three scenarios are explained and the results of the particular market estimations are shown.

1) Base scenario

This scenario describes the progress concerning automated vehicles, how it is considered to be most likely. The assumptions for the scenario are as follows:

- Moderate legislative progress (adaption of law and liability systems for autonomous driving in use cases until 2022)
- Normal technical progress (autonomous driving in use cases possible from 2022)

Further assumptions are a standard price decrease of the model of 5 % p.a. and no specific legislative restrictions or incentives.

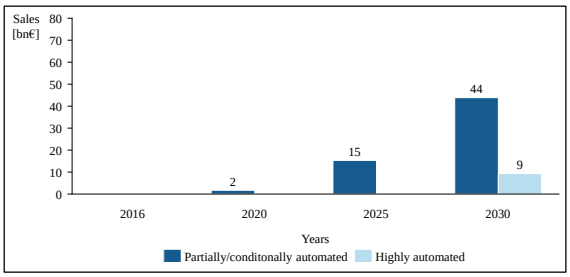

Fig. 2 – Revenues created by automated systems in base scenario

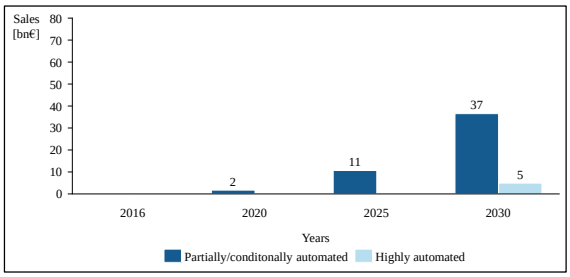

Fig. 3 – Revenues created by automated systems in low scenario

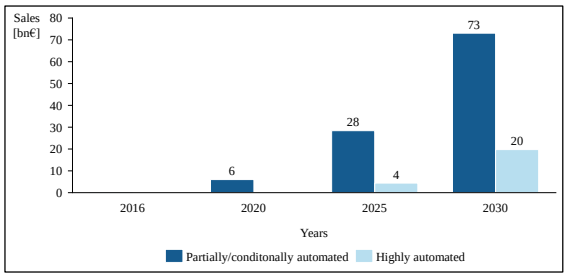

Fig. 4 – Revenues created by automated systems in progressive scenario

By that, the revenues for automated systems are estimated to be 2 bn€ in 2020, 15 bn€ in 2025 and 53 bn€ in 2030, of which 9 bn€ can be accounted to highly automated systems. This is illustrated by Fig. 2.
It can be noticed that highly automated systems, being introduced in 2028, show a faster market capitalization than their predecessors. The reason for this is that customers are assumed to be more familiar with the fact, that they are no longer steering their vehicle by their own but hand over the control to a computer.

2) Low scenario

The low scenario is based on the following assumptions:

- Slow legislative adaption (fully legislative approval of autonomous driving in use cases by 2025)
- Normal technical progress (autonomous driving in use cases possible from 2022)

Similar to the basic scenario, the price decrease of the features was assumed to be 5 %. In this case, the revenues for level 2 and 3 features were estimated to be 2 bn€ in 2020, 11 bn € in 2025 and 37 bn€ in 2030, whereas highly automated features are responsible for a 5 bn€ market in 2030. This results to a total market for automated driving features of 42 bn€. The particular revenues are illustrated in Fig. 3.

3) Progressive scenario

The last scenario is the progressive. In this case, it is assumed that the legislation keeps up with an accelerated technical progress, which leads to an earlier introduction of automated driving and parking systems. Furthermore, some components are becoming commodities, resulting in an assumed price decrease of 6% This causes a higher market penetration and higher revenues created by automated systems. These revenues are illustrated in o Fig. **4**. Thus, automated systems are estimated to be responsible for a revenue of 6 bn€ in 2020, 32 bn€ in 2025 and 93 bn€ in 2030, of which 4 bn€ in 2025 respectively 20 bn€ in 2030 can be accounted to highly automated systems. By that 12 million highly automated vehicles are expected to be on the roads in 2030.

C. Discussion of results

All three scenarios show a comparatively fast market introduction of automated systems. Its velocity is mainly depending on the years of system introduction which again depend on the technical progress and the legislative adaption to enable self-driving vehicles. The former is expected to accelerate in the upcoming years, due to the stronger competition, the further increasing capability of computers and the rising connectivity of vehicles, whereas legal aspects hold many open questions. Especially the moving from conditionally towards highly automated systems, defined by the elimination of a backup represented by the driver, is a major legislative issue. Subsequently, the installation of a legal framework and the accomplishment of technical key challenges will drive market launch, installation rates and revenues created by automated systems.

IV. Influence of Autonomous Driving on the Automotive Value Chain

To which consequences for the automotive industry does this lead? So far, the topic was discussed from a market perspective analyzing the possible OEM revenues. This chapter will dive deeper into the automotive value chain for assisted and automated systems. The value chain is analyzed in detail and the implications of an increasing degree of automation is shown.

A. Cost drivers of assisted and automated systems

Strategy Engineers divides the value chain for assisted and automated systems into three categories, which are on-board systems, car-to-x/connectivity systems and on-board system integration.

1) On-board systems

On-board systems contain hardware components and software solutions, which can be further divided into several subcategories. Fig. 5 gives an overview of the according components and systems.

2) Car-to-x/connectivity

Car-to-x/connectivity systems are, in this case, all communication and network systems which are considered to be necessary for automated systems/ autonomous driving, including car-to-car ad-hoc-network, car-to-infrastructure systems and the embedded modem.

3) On-board system integration

On-board system integration includes the implementation and integration of the components, or systems respectively, on functional, powertrain, chassis and vehicle level.

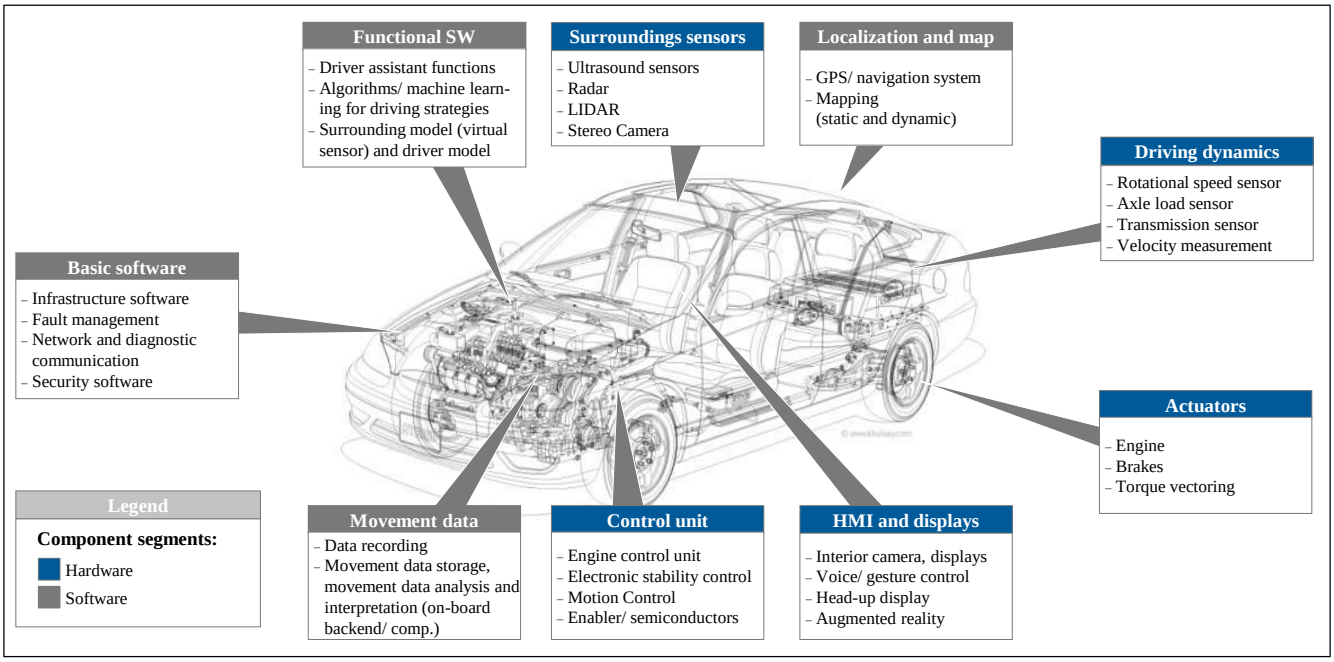

Fig. 5 – On-board systems for assisted and automated systems

B. *Influence of highly automated systems on system component costs*

Based on this segmentation, the costs for automated systems can be allocated to the different value chain elements. Fig. 6 illustrates the cost distribution for partially automated systems in 2016 and highly automated systems in 2025.

1) Current costs of a partially automated system

In 2016 the averaged add-on costs for a vehicle equipped with partially automated features are estimated to amount to 500 € in total. On-board systems are the biggest cost position with a share of more than 80 %. Within these, hardware costs are responsible for most costs with surrounding sensors accounting for one quarter of the total add-on costs. The total software costs are 130 € per vehicle, while the costs for on-board system integration and car-to-x/connectivity are comparatively low, with 80 € and 10 €.

2) System component costs in 2025

The component costs for the systems will increase with the degree of automation since they have to be capable to handle more complex situations. These require a higher computer capacity and more advanced sensors and software solutions. Additionally, autonomous driving systems have to be able to communicate with their environment and other cars to ensure safe driving. This drives car-to-x/connectivity systems to have the strongest relative increase (by 3200 % from 10 to 330 €). Next to connectivity-based systems, human-machine-interfaces (HMI) and localization and mapping show the biggest relative growth. These components are described in greater detail:

- *HMI:* Autonomous driving will lead to a shift of the customer's buying criteria for cars. With increasing automation, the importance of motorization and handling will decrease and human machine interfaces will become a crucial differentiation factor for automated vehicles. OEMs also will have to reduce the length of their product development and introduction cycles to 12 to 24 months in order to match the pace of multimedia companies competing for the non-captive time of the customer, induced by autonomously driving vehicles.
- *Localization and mapping:* Conditionally and highly automated vehicles will not only depend on their surrounding sensors and the according software to localize themselves. In fact, they will rely on the use of accurate maps and localization system to determine their positions. The development and integration of these systems determines capabilities and reliability of automated systems and will lead to rising costs.

The add-on costs for automated systems in 2025 in total are estimated to amount to 2,900 €, wherein the costs for software solutions are 750 €, 420 € for system integration and 1,200 € for hardware. The costs for the latter could even increase, depending on the sensor solution to be used in autonomously driving cars. The add-on-costs for automated systems in 2025 in total are estimated to amount to 2,900 €, wherein the costs for software solutions are 750 €, 420 € for system integration and 1,200 € for hardware. The costs for the latter could even increase, depending on the sensor solution to be used in autonomously driving cars. The current options are light detection and radar (LIDAR) systems, which have to show a significant cost decrease, or combinations of conventional sensors (camera, ultrasound, radar), which have to prove feasibility.

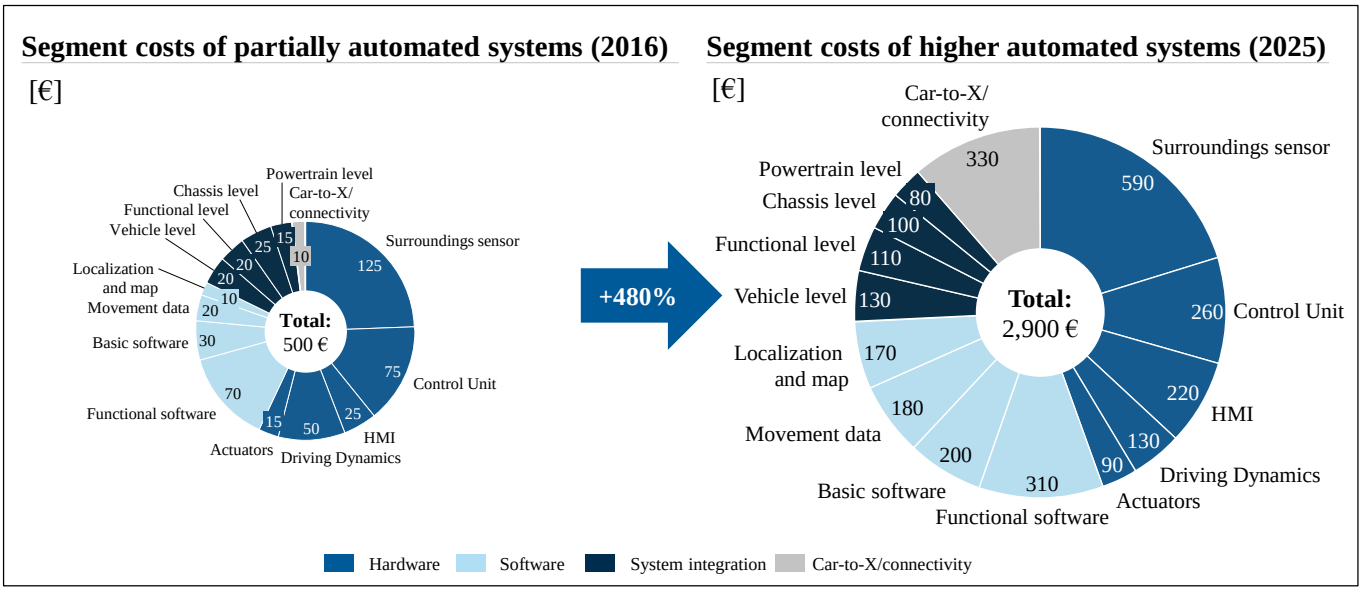

Fig. 6 – Segment costs for automated systems in 2016 and 2025

C. Players accessing the different segments

The increasing importance of automated systems and their components represent an attractive business opportunity for players outside automotive. Furthermore, automated systems require components, in which competitors have advantages which are not originally rooted in the automotive industry. Examples for these are given in Table 3. Following are some insights on the new entrants to the market:

- *Focus:* While traditional automotive players (OEMs and suppliers) are distributed over all segments of the value chain, new players can chose the competition fields based on their strategic advantages: multimedia companies focus on customer interfaces like HMI and functional software solutions, whereas e.g. IT companies concentrate on software solutions. Nevertheless, some companies intend to diversify their portfolio and are working to access fields far off their traditional competencies (first to mention Google in vehicle level system integration).
- *Size:* Smaller companies and start-ups prefer specialized components, whereas companies like Apple and Google intend to offer more holistic solutions in order to supply the customer with brand-specific services. Those companies tend to see an automated vehicle as new hardware platform on which they can implement smartphone-proven, established software solutions with little adjustments to the new product "car".
- *Geographic distribution:* Whereas all over the world mostly established automotive companies, both suppliers and OEMs, are working on autonomous driving solutions, the USA are a flouring field for start-ups. The majority of these young companies is located in California in direct proximity to the "big innovators" like Apple, Google and Tesla.

TABLE 3. SELECTED EXAMPLES FOR PLAYERS IN COST SEGMENTS

ON-BOARD SYSTEMS									CAR-TO-X / CONNECTIVITY	ON-BOARD SYSTEM INTEGRATION			
Software				Hardware									
Functional software	Basic software	Movement data	Localization and map	Surroundings sensors	HMI	Control unit	Driving dynamics	Actuators		Vehicle level	Functional level	Chassis level	Powertrain Level
Automotive industry													
OEMs, suppliers	OEMs, suppliers	OEMs, suppliers	OEMs (e.g. Here)	Suppliers	Suppliers, OEMs (R&D)	Suppliers	Suppliers	Suppliers	Suppliers	OEMs	OEMs, suppliers	OEMs	OEMs
New players / players from other industries													
Microsoft, Mobileye, Valeo	Microsoft, nvidia, IBM		Google, Apple, TomTom	Quanergy, Velodyne, Cruise, Valeo	Google, Apple, Microsoft, Intel	Nvidia, Texas Instrum., Valeo, Infineon	-	Valeo		Google, Internet Smart Electric Car	Mobileye, Cruise, Nauto		-

Nevertheless, there are some promising exceptions in the rest of the world, in Europe for an example Mobileye or Internet Smart Electric Car from China.

The analysis shows that competitors for automated system are entering the automotive value chain across almost all segments. They will compete with traditional and established players, both having advantages in specific fields. In Chapter VI this topic is discussed more detailed.

V. New business opportunities enabled by highly automated vehicles

Besides their impact in the value chain, highly automated cars have further potential to reshape and shift the revenue pools within the automotive industry in the long term. Induced by autonomously driving vehicles and the increasing connectivity, new business opportunities are developing and new players will push into the automotive market, aiming at both traditional domains of established automotive players and new unexploited fields.

A. Enablers

Starting point for these changes are the benefits of highly automated vehicles. In fact, these vehicles allow the driver for the first time to neglect her/his original driving task in particular use cases, without the responsibility to serve as a backup. New business models seize these benefits and implications, profiting from enabling factors, which are listed in the following.

1) Autonomously driving vehicle

Starting with high automation, the driver is not any longer required in the vehicle. Thus, specific tasks, e.g. parking, can be executed autonomously by the car. With a further increase of automation (level 5), entire new business models can be developed and established models, e.g. taxi services, will face fundamental changes.

2) Increased non-captive time of driver/customer

Another entry point for new business models are use cases of autonomous driving, in which the driver will not be the pilot of the vehicle but solely a passenger. By that, she/he becomes a potential customer for the time in which the vehicle is driving autonomously and which is not any longer "captured" by the driving tasks. The usage of the emerging non-captive time will be a crucial factor for competitors in automotive after-sales/services.

3) Connectivity

Generally, the number of connected cars is increasing and for autonomously driving vehicles (especially level 5), connectivity is a must. First of all, the cars have to be connected to other vehicles (V-to-V) and to the infrastructure (V-to-I) to be up-to-date with changes of traffic regulations and roads because of e.g. construction works. Furthermore, they will be connected to the internet and especially this brings an immense potential for new business opportunities. Various new connectivity players are expected to enter the automotive value chain.

B. Derivation of new business models and potential competitors

These three factors enable new business models based on higher automated vehicles. Generally, these models can be divided into in-car, car-related and car-independent services. In the following, the three categories are introduced, examples for revenue pools and business models are mentioned and selected traditional and new competitors are shown. Table 4 gives an overview of those business models.

1) In-car services

In-car services include all web- and connectivity-based services as well as smartphone integration in the car. Originally, these services do not depend on autonomous driving, but the automation of vehicles will accelerate the connected businesses due to the increased non-captive time, as explained above. Both web-/connectivity-based services and in-car smartphone integration have two common main target areas, which are entertainment and e-commerce. With an increasing degree of automation, the vehicle will serve as "mobile living room and office" and will become a more and more attractive business opportunity. The integration of the mentioned topics will become a major challenge for OEMs if they do not want to give up the close relation with their customers after having sold the car. At the same time multimedia companies like Apple and Google are entering a market in which they have major advantages compared to OEMs, e.g. a superior knowledge on the customer's requirements in terms of services. The OEMs on the other hand, do still produce and sell the cars and determine the vehicle's capabilities and compatibilities. In-car services are about to become a crucial differentiation factor for automotive players and their vehicles in any case.

2) Car-related services

Under the umbrella car-related services all physical services are united, which are directly related to the vehicle. They aim on the usability of the car and include parking and mobility services, like car rental, car sharing and taxi services. While the possibilities for (off-car) parking services are comparatively limited, e.g. automated vehicle parking spots/garages based on car-to-x communication systems, mobility services provide a very wide field of opportunities. Moreover, this area will develop its full potential when full automation (level 5) will be reached. Taxi services, car rental and car sharing services will assimilate, since their main differentiating element, the driver no longer required. The emerging services will only be distinguished based on the different ownership models and specific purposes of the services (e.g. rental/sharing of highway cars).

Nevertheless, this development holds many chances for OEMs and new competitors. For OEMs, the chances of an extension of their car-sharing concepts is possible, while the latter can offer cheaper services by having eliminated the most expensive cost factor in their value chain: the driver!

TABLE 4. NEW BUSINESS MODELS

	In-car services		Car-related services		Car-independent services		
	Entertainment	**E-commerce**	**Parking**	**Mobility services**	**Smartphone applications**	**Intermodal travel solutions**	**Data processing**
Examples	Streaming services, smartphone integration	Customized offers for car users, mobile shopping	Parking spots for automated cars, valet parking garages	Car sharing, car rental, taxi services	Location- and community-based applications	Public transportation, connection of travel concepts	Processing and use of big data
Competitors	OEMs, Apple, Google, other multimedia companies	E-commerce service providers, multimedia companies, OEMs	Private car parks/garages	OEMs, mobility service provider (e.g. Uber), car rental service provider	Start-ups, B2C internet companies, (OEMs)	Start-ups, public transport provider, OEMs	Multimedia companies and IT companies

3) Car-independent services

The last category of new business opportunities emerging from an increased degree of automation of cars are car-independent services. These include intermodal mobility solutions, (big) data processing and location-/community-based smartphone applications, which are not directly linked to a car. Intermodal travel solutions or even new mobility concepts including automated cars aim at efficiency of transport/travel and could be an example for the connection between a purpose-built highway car and (sub-)urban public transport. Location- and community-based smartphone applications mainly aim at the well-being and entertainment of the customer and offer e.g. customized offers dependent on the location. Since those two service areas are comparatively new and seem to be promising, many start-ups and large B2C internet companies compete with traditional automotive players in this field. The third category of car-independent services is data processing, which has always been an IT-company domain and this is not expected to change with automated cars. This segment includes all big data services, the usage and processing of the data and the connected derivation of information and therefore is an area, in which automotive players can and will not compete with the established players, like e.g. Google or IBM.

VI. CONSEQUENCES FOR AUTOMOTIVE PLAYERS

As shown in the previous chapters, most of the promising opportunities emerging from the introduction of higher automated vehicles are accessible for established automotive players with risks and chances in every field. To meet these challenges, automotive players have to decide how they want to approach the competition and how to position themselves in order to face the upcoming changes in the industry.

A. Value chain for higher automated systems

In Chapter IV, the cost segments of assisted and automated systems and their development were analyzed. Further, the availability of the value chain segments for automotive players and new entrants was discussed. Based on this, several implications can be evolved for automotive players and their future strategies. They have to decide how to position themselves according to their individual competencies, capabilities and claim in order to differentiate from competitors.

1) Implications for automotive players

The attractiveness and importance of a value chain segment depends on three main factors: Differentiation potential, innovation potential and financial potential. Based on these factors, the positioning of different players can be explained. Additionally, some segments are crucial for certain players, so is e.g. system integration an essential OEM domain. In the following, examples are given for each of the factors.

- *Differentiation potential:* HMI, functional software and vehicle integration show the greatest differentiation potential within the value chain for automated systems. As mentioned before, vehicle integration is a traditional OEM domain and an essential differentiation factor between them. Further, HMI and functional software solutions will be important characteristics of higher automated vehicles. Both are aiming on the customer-vehicle interface and the usability of the automated system. Since the systems define the driving experience, they will become a crucial buying criteria. This makes it indispensable for automotive players, not to focus on these components.
- *Innovation potential:* According to Strategy Engineers' analysis, HMI and functional software solutions, together with surrounding sensors, have the highest innovation potential. This is based on the requirements of higher automated vehicles and the change, which these components will experience. The functional software solutions and surrounding sensors of an autonomously driving car have to provide much more capabilities in order to solve this complex task. While the latter are expected to become commodity in the future, the former is an interesting field, as it determines the sophistication of the technology. HMI on the other hand, has to be adapted to a customer who is no longer driving the vehicle but can dedicate his time to other things. But based on the high innovation potential, all three segments will undergo a stronger competition due to the high number of market entrants aiming on this opportunity. This development can already be noticed in the present (compare Table 3).
- *Financial potential:* From a financial point of view localization and mapping, HMI and car-to-x/

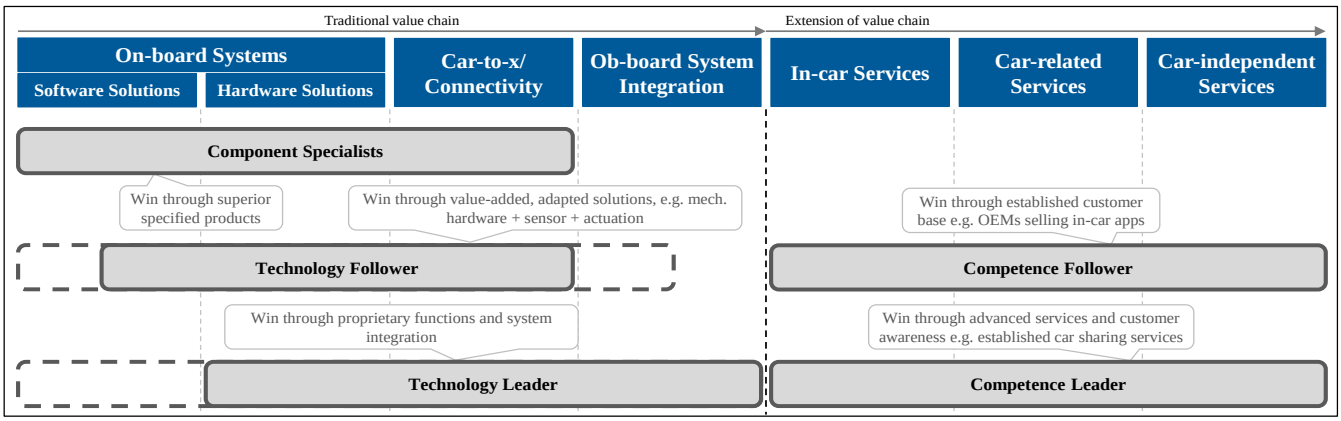

Fig. 7 – Positioning strategies in the value chain for automated systems

connectivity systems have the greatest potential, as shown in Fig. 6. All of them show a big increase of their relative cost share in the systems in future, due to their growing importance in proportion to the degree of automation.

Conclusively, it can be stated, that functional software and HMI will become crucial factors for OEMs and suppliers. Further interesting fields are connectivity systems and surrounding sensors, whereas the latter will become commodity in the future. At the same time, these segments will experience the most significant increase in competition.

2) How to approach

To win in this game, automotive players have to decide whether they want to lead the competition or to follow and profit by adapting market-proven products. A third strategy is to focus on specific components. This mainly applies for smaller tier 2-X suppliers.

a) Leading the competition

To lead the competition for automated vehicles, automotive players have to invest strongly in R&D efforts to be the first to market providing new systems. Since automated systems are very complex and include several functions and components, the according R&D activities are an advanced challenge. Based on that, they have to be highly coordinated in order to ensure a holistic and perfectly balanced system. This includes efforts in operational management and R&D efficiency, but may ensure the differentiation from competitors. On the other hand, this strategy implies higher risks in terms of system validations, technical failure and costs. Especially, higher automated systems imply these risks due to the complexity of the systems and the numerous constraints and barriers which have to be considered.
Addresses: Premium OEMs, global tier-1 suppliers, new entrants (e.g. Google)

b) Following the competition

In contrary to the first approach, automotive players can "follow" the competition and put their efforts on a quick adaption of sophisticated and successful technologies. Their R&D efforts focus on the further development and advancement of existing, market-approved technologies. In case of automated systems, this could e.g. be the adaption of the sensor configuration of a successfully introduced autonomously driving vehicle. This approach generally results in a lower R&D cost structure, which allows the competitor to offer lower initial prices leading to a faster market capitalization. Nevertheless, there is the risk to miss the opportunity like it was the case for many OEMs in voice control.
Addresses: Volume OEMs, OEMs in emerging markets, tier-1 suppliers (e.g. commodity suppliers)

c) Specialisation

Another way to approach the development of higher automated systems is to specialize on certain parts of the systems. Especially smaller companies can follow this strategy in order to achieve competitive advantages in a specific segment. The achievable margins depend on the particular components and the integration level into the supply chain. Due to the very specialized tasks of several software and hardware components, automated systems offer the perfect starting point for these component specialists, which can be automotive players or new entrants. The latter can either be start-ups or players from other industries, which are profiting from synergetic effects.
Addresses: Tier-1-X suppliers, new entrants (e.g. Mobileye, Cruise, IT companies)

B. Analysis of business opportunities derived from autonomous driving

As described in Chapter V, autonomously driving vehicles form the base for several new business opportunities for both automotive players and new entrants. In the following the implications of these developing business areas and the possible approaches for automotive players are discussed. Since the majority of these opportunities is mainly accessible for OEMs, start-ups and players from other industries, this section will focus on the consequences for those companies and the emerging competition.

1) Implications for automotive players

Autonomously driving connected vehicles bring several chances for OEMs, if they use their traditionally established competitive advantages. This requires a rethink within the

automotive industry. The view of the customer from an OEM perspective must no longer limit on the purchase process and the maintenance of the vehicle. Furthermore, the OEMs have to target a holistic customer, who buys the vehicle and stays connected to the maker of the vehicle he is driving. OEMs will have to find ways to further meet customer's needs with services which may not be directly related to the vehicle itself. Thereby, especially the usage of the non-captive time while the vehicle driving autonomously has to be the target of OEMs. However, OEMs may need to partner concerning this topic since multimedia and e-commerce companies do possess competitive advantages in the service area. Nevertheless, OEMs might be able to use their superior knowledge on their product to profit from this development.

2) How to approach new business opportunities

Similar to the automotive value chain, there are different ways to approach the development of services or competencies respectively.

a) Leading the competition

In order to be the first in market, both OEMs and new entrants have to develop the services by their own. This requires advanced market research and the ability to react flexible to market requirements. Due to the high number of competitors in this field, OEMs should focus on their main competitive advantage which is, as mentioned above, the superior knowledge of the vehicle. By implementing the solutions within their in-car systems in form of sophisticated services for entertainment, e-commerce or well-being. Furthermore, OEMs have to adapt the flexible product/service development cycles of the according industries in order to achieve leading positions in the after-sales services. Alternatively, they can try to partner with multimedia companies to profit from synergies between the two industries.

Addresses: OEMs (through e.g. advanced infotainment systems), new entrants (e.g. Uber, app developer)

a) Reactive approach

The second way to approach new business opportunities, is to follow the competition and to react on promising developments. OEMs can rely on their strong brand names and use it to introduce adapted services developed by competitors. Alternatively, OEMs can use their financial power to acquire promising start-ups, whereas this strategy has one big weakness, since investors drive the prices for these "stars" in astronomic heights. By following a reactive approach, OEMs can focus on their traditional domains and reduce the risk of entering a new developing, low sophisticated market. Furthermore, they do not face the direct competition with established service providers. Nevertheless, this strategy brings the risk to become a pure hardware provider and to miss the chance to profit from the promising revenue pools, generated by autonomously driving vehicles.

Addresses: OEMs (through adaption and advancement of services), new entrants

Generally most OEMs are expected to aim on a mixture between both approaches. Fig. 7 illustrates the different positioning strategies for automotive players across the value chain for automated systems.

VII. Conclusion

The introduction of automated vehicles will change the automotive industry forever. By 2030, more than 11 million automated vehicles are expected to be on the roads, of which 2 million are assumed to be highly automated. The according feature sales are estimated to reach 53 bn€ per year, with a strong further upward potential. Additionally, the development of new business models and the extension of the traditional value chain is assumed to lead to significant revenues, which are not further quantified in this paper. These revenues are expected to be predominantly accessible for new industry players but as well as for traditional automotive companies if they adapt to the new market conditions in time.

Based on the increasing degree of automated vehicles, the traditional automotive industry faces several changes in its established value chain. Generally, the sophistication of higher automated systems is determined by software solutions and connectivity systems, while the costs are driven by surrounding sensors and control units. Furthermore, higher automated systems require higher capabilities from the components (e.g. control units with higher computer capacity or more sophisticated functional software), which will lead to a shift of the importance of these particular components. Induced by the connected revenue shift, new competitors are entering the industry aiming at the innovation potential of the components. Functional software, HMI and connectivity systems are facing the strongest competition due to their crucial importance for highly automated systems. OEMs have to adapt capabilities of their future competitors, e.g. shorter and more flexible product development circles, in order to compete with them in the particular value chain segments and to maintain the customer's acceptance.

Besides these changes, highly automated vehicles will revolutionize the established automotive value chain and open new business opportunities in the after-sales/service market. While traditional automotive companies see the customer only as buyer and driver of the car, autonomously driving vehicles downgrade the driver to a passenger. Paired with the increasing connectivity, the emerging captive time represents a promising opportunity for both OEMs and new entrants.

VIII. About the Author

Strategy Engineers is a leading strategy and management consultancy with a focus on the automotive sector and closely related industries. From offices in Germany and China, Strategy Engineers supports its clients in business and growth strategies, product optimizations as well as in productivity improvements in the fields of research & development, operations management and sales, marketing & after-sales. Strategy Engineers actively participates in the industry and has successfully accomplished several projects concerning ADAS and autonomous driving.