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Report on the assessment of the business models

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1 Introduction and presentation of Business Models

In task 4.1 of work package 4 “Identification of Sustainable Business Models”, four valid business models were picked and explored. These business models are namely: 1. “Connected maintenance and safety”, 2. “Automated valet parking”, 3. “Automated truck platooning on motorways” and 4. “The car as digital experience center”.

The first business case “Connected maintenance and safety” is mainly a series product since the core element for safety of this business case is the so called “eCall-System”, which is mandatory for all new vehicle models introduced into the market after 31st March 2018 [1]. The second component of this business model is the connected maintenance service, which shall prevent the sudden breakdown of a vehicle and might also offer the possibility to remote control the vehicle to recover it after a system failure. This part of the business model is yet to be realized. Even though the business model doesn’t fit the level 4/5 scope of the SCOUT project (regarding the SAE specifications), it is a fitting example to show the technical and legal deployment as well as the user acceptance nowadays. Furthermore, the maintenance part could be further developed to level 4/5 functionalities as an autonomous car could schedule its own maintenance checks or garage visits in service free periods.

Automated valet parking, as the second business model mentioned in deliverable 4.2, is the next level of automation of parking tasks, from which several evolutionary steps are already transferred into series products. Figure 1 shows a roadmap of the steps towards automated valet parking systems of a Tier1 supplier and the required equipment of the vehicle [2]. Roughly described, after leaving the car in a drop-off zone of a parking garage, the vehicle will find its own way to the parking spot and can be called back via app to leave the parking garage and pick up the driver again in the drop-off zone. Automated valet parking can be understood as an autonomous, low speed maneuvering function in a parking space environment.

When considering automated truck platooning on motorways, the automated driving function must also be capable to operate in higher velocity ranges of at least 60 km/h to be licensed to drive on motorways. The implications for the required equipment of the trucks, in combination with the higher weight of the trucks, are tremendous. The goal is to build truck platoons, i.e. several trucks following each other with a reduced distance, to gather benefits like reduced fuel consumption, leaving the driver’s seat to concentrate on different tasks or to gain more flexibility in driving hours and similar things. The driver in the leading vehicle guides the other trucks behind him to follow the lane and drive at a constant speed and distance. With regular changes in the platoon leading position, drivers in the following trucks can use the time for mandatory breaks and reduces operational downtimes hence increasing transport efficiency.

The last business model mentioned in the deliverable is “the car as digital experience center”. The basic requirement for this function and all similar functions is the availability of at least a fully operational level 4-functionality or higher according to the SAE specification [3], thus it is a look far ahead of what is state-of-the-art and most likely beyond the 2030 scope when it comes to mass production. The implementation in the premium sector and especially fleet operational vehicles in restricted areas are expected well before 2030 (see e.g. Waymo in Arizona). This would mean that the driver is no longer necessary as a fallback layer, and the vehicle must be able to transfer into a safe state without human interaction. To realize such a function, beside the software modules of automated driving like perception, localization, behavior generation, trajectory planning and controls, the hardware must be redundant and fail-operational to be still functional even after a system failure. As soon as this topic is solved, the adaptation of the interior and the connection to external services is a minor challenge.

The business models described in deliverable 4.2 vary greatly in terms of timing of possible market introduction, maturity of the needed technical solutions, the legal framework and the acceptance of the customers for these functionalities. These topics will be addressed during the assessment in chapter 2.

2 Assessment

2.1 Connected maintenance and safety

The connected maintenance and safety function is already (at least partly) a mandatory function for new vehicles, i.e. the technical feasibility is already approved and series products are available. Also, the legal framework is defined, which makes the eCall mandatory and as long as the customer has no choice to use the system or not, the threshold of acceptance is not an issue. This is different when considering the connected maintenance service which might cost a fee. In the following paragraphs, the three pillars of the technical solution, the legal framework and the acceptance from customer or user's perspective are evaluated.

2.1.1 Technical

The basis of the function is a connectivity module to establish a direct connection between the vehicle and a public safety answering point (PSAP). For the eCall system, the emergency voice call (E112) is used for the best available connection regardless of the operator. Without a life critical situation (in case of a maintenance or breakdown), it is not possible to use the E112 channel to establish a connection to a breakdown service. If no reception of the operator is available, the service could be useless.

As a localization solution, a global navigation satellite system, like Galileo or GPS is required, but each navigation system uses the same information and these systems are broadly available. The quality of a standard Galileo or GPS receiver is sufficient for this task since no exact lane position is required.

The eCall system sends a "minimum set of data (MSD)", which is defined in the standard EN 15722:2011 'Intelligent transport systems — eSafety — eCall minimum set of data (MSD)' to the PSAP and therefore needs to have access to some in-vehicle sensors.

Currently there is no definition of a MSD for a breakdown service and also no definition of the correspondent institution compared to the PSAP. Therefore, both need to be defined and established before expanding the system to the breakdown service as well. Several technologies that are considered in vehicles like a cellular connection and V2X communication could serve as carriers for such a service. As a broken down car on a highway poses a threat for road safety, a service enabled by road infrastructure providers via V2X roadside units considers a mobile and cellular subscription free service.

2.1.2 Legal framework

The legal framework for eCall systems is defined and the need to comply with personal data protection rules is also clearly stated in the regulation 2015/758 [1]. The driver /car owner has the possibility to choose between the PSAP and a service point of his provider, which enables him to keep his data privacy as the PSAP only receives the MSD. This regulation could also serve as a basis for the breakdown service although the focus of the regulation is solely on eCall systems. As mentioned above, it has to be defined which kind of data is transferred to which service point to keep the driver's data privacy.

2.1.3 Acceptance

One study, which was conducted for both systems eCall and breakdown or maintenance services show a huge commitment of the attendees to use an eCall system in their vehicle. The positive arguments like faster rescue, rescue possible if driver is no longer able to actively make an emergency call or better discoverability outweigh the concerns about privacy or permanent surveillance. The acceptance to use and send personal data to other parties outside of life critical situations is significantly lower. Most of the attendees refuse sending any data automatically to third parties, but also automatic sending of pre-defined data is mostly not accepted. The driver wants to be the host of all data and wants to choose by himself, when and which and to whom any personal data is sent. Overall it can be stated that if there is danger to life, the users are willing to share any information which helps to save lives, for other extra services they are more critical. [4] But when looking at other already available services outside the automotive scope where personal data is shared like e.g. Facebook or Instagram, it can be stated that the willingness to share personal data is influenced by the convenience. As long as the user feels an added value, his willingness to share personal data is much higher. But when looking at recent data leaks and the public reception resulting out of the publication the need for a reliable data ownership is needed like it is done with the PSAP.[1]

2.2 Automated valet parking

On the way towards automated valet parking, several evolutionary steps have already been made and multiple series products have evolved. After the well-established informative system, which only gives acoustical and/or visual feedback of the surroundings to the driver, the first automation level was letting the system take over steering control and letting the driver accelerate and brake and also shift gears if necessary during multiple sweep maneuvers. The next steps to add more comfort is to let the system also take over the engine control having the driver as an observer either sitting inside the vehicle pressing a button during the maneuver or standing outside with a remote control, also pressing a button or executing a gesture during the whole maneuver. First products like the car-key-remote control can be seen in BMW 7 series[2].

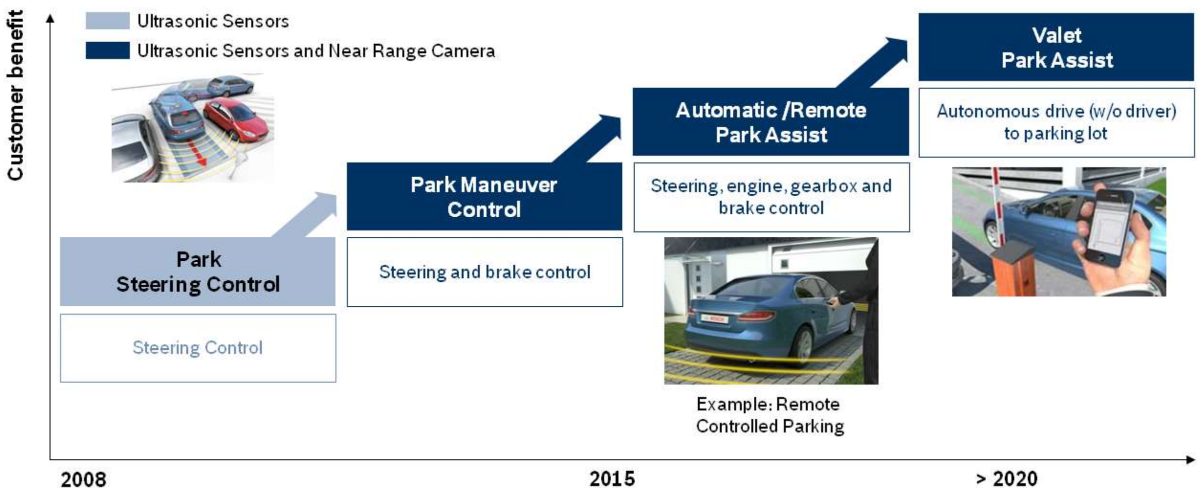

Fig. 1: Example of roadmap for automated parking (Source: Bosch)

[1] https://www.theverge.com/2018/4/10/17165130/facebook-cambridge-analytica-scandal

[2] https://blog.nxp.com/connected-car/hello-remote-control-parking-and-goodbye-parking-stresses

All systems, that take over at least one control task from the driver can be found in Fig. 1. This roadmap is shown as an example, but many suppliers offer similar systems. Beside the already introduced systems, this roadmap indicates the long-term goal to offer an autonomous valet park system. Technology demonstrators for automated valet parking in a defined area have been shown for example by BOSCH[3].

2.2.1 Technical

While automated parking systems of level 1 and 2 are mainly based on ultrasonic sensors to detect obstacles in the surrounding area and hereby find a suitable parking spot, for an automated valet parking system, the sensor set needs to be enhanced. There are three different technical solution categories to consider. The vehicle itself having the sensor and processing to self-decide on its actions while finding a parking spot and executing the parking maneuver. The second is an infrastructure-intelligence where the parking infrastructure gives the vehicle low-level action commands like forward, backward, left and right through wireless communication and thereby steers the car into the destined parking space. The third option is a fully automated parking infrastructure where the vehicle is dropped off on a pod-like structure which is controlled by the parking infrastructure. In all cases safe operation needs to be warranted at all times. The system architectures hence need to also account for multi-decision paths using different sensors and processors as well as different kind of sensors and processors depending on the reliability of each such sub-systems to achieve the required system reliability. Same applies for safe execution of commands by the actuation system. sets should be redundant as well as the actuators. As option three does not require autonomous driving features in a vehicle we will not further discuss it.

Continental, a large automotive supplier, takes the first approach and avoids the need to equip the parking garage with environment sensors. The vehicle itself carries the redundant sensors, namely four short range radar sensors, four surround-view cameras and one front facing mono camera. This approach was demonstrated as a show case, but Continental plans with a series start in 2022 without saying which hurdles they still need to overcome till then. [7]

By Daimler and Bosch, we see a pursue of a system as described by the second category. They equip the parking garage with environment sensors and add a communication layer between parking garage and vehicle to transfer data like parking spot position or other objects in the parking garage. The redundancy in sensor technology is solved with the combination of on- and offboard sensors. The vehicle sensors prohibit action commands that would lead to collisions while the central processing on the parking infrastructure monitors the free space and calculates trajectories[5][6]. How reliability and respective redundancy in actuators is solved, is not mentioned by Bosch or Daimler, but due to the limited speed during parking maneuvers, the parking brake could be accessible by wire and activated in case of system or communication link failures.

2.2.2 Legal framework

Today's systems which include park maneuver control are covered by the regulations in place, which refer to the Vienna Convention for the EU-member-states. But when it comes to the next level of automated park assist and ultimately the autonomous drive to the parking slot, there are still legal hurdles in place. This is namely the need to have a driver in place and in control of the car

[3] https://www.bosch.com/explore-and-experience/automated-valet-parking/

or the system driving it. This won't be the case for the "Valet Park Assist" in Fig.1. Therefore, further amendments would be needed to enable this use case on public roads.

That said, most parking garages are operated by private stakeholders on private ground where the rules for public roads not necessarily apply. The same applies to public operated parking garages / houses which are often operated by private companies owned by the city. This means in the end there is a gap in the Vienna Convention for this use case.

But using this gap still triggers other legal issues such as liability, insurance and as a result type approval. All these legal issues have to be rectified before deploying this use case to have legal security in the event of a crash/damage. Considering the fact, that the damage would occur at low speed and without human beings involved, the financial damage would most likely be within a limited frame which leads to the conclusion that these are minor hurdles to overcome.

As soon as the use case expands to public roads in e.g. inner-city environments the Vienna Convention comes back into play and needs to be adapted accordingly.

2.2.3 Acceptance

A study conducted in 2012 already indicates that drivers rather hand over their car to get it parked instead of searching a parking spot and maneuvering into tiny parking spots with the risk of damaging the car.[8] Thus, the authors of the paper assume that it makes no difference for the car's owner if another human parks the car or an automated system.

Overall, the costs associated to searching for parking spots in form of wasted time is enormous. Reference [9] mentions that on average every driver wastes 100 hours per year searching for parking spots and they drive approx. 4.5 km until they find a suitable spot. The numbers reported from [10] for wasted time during parking spot search vary over countries: The average driver (based on the 30 biggest cities from US, UK and Germany) spends 17 hours per year, while in the U.K. and Germany, it is more than 40 hours and in huge cities like New York City, it can be more than 100 hours per year. When looking at the costs of $345 for U.S. drivers, £733 in the U.K. and €896 in Germany [10], probably every driver wants to reduce these numbers and if automated valet parking could help. It seems to be likely that the driver would accept this technology. Furthermore, there is no real need to share any personal data and with an easy to control area and low speed the safety issues are nearly non-existent too, which should lead to a high user acceptance. The only foreseeable hinderance in user acceptance could be a high price for the customer for this added functionality which acceptance depends on the perceived value such a system brings the customer. As the above mentioned numbers are statistical, they do now reflect the perceived loss of the driver which in the end is the decision factor.

Another application field that might enable the market could be ride sharing offers like Car-to-Go, DriveNow and others. The user could decide to properly park the car or just get out anywhere and pay a service fee for the car to return to a valid parking spot for the next pick-up. Due to higher utilization rates of ride-sharing vehicles, costs can be shared and sold as a service feature.

2.3 Automated truck platooning on motorways

Automated truck platoons on motorways have shown their potential to increase traffic and energy efficiency [11], [12], [13]. The benefits and challenges of truck platoons depend on the system configuration. Shorter gaps in between trucks for example increase the potential to save fuel [13], but as system latency reduces system complexity rises. This makes it extremely important to consider the system configuration when interpreting results from truck platooning studies.

2.3.1 Technical

Basis of every platooning system is a V2V communication between all trucks of a platoon [14]. Therefore, IEEE 802.11p technology based radios are used. A redundancy of the wireless transmitted information is ensured by different transportation channels and more than one radio in today`s systems. Systems have to ensure a robust and secure communication. To enable the minimum platooning functionality, every truck platoon system has next to the communication system a front looking radar sensor for distance control and AEB [11], [14]. Depending on the platoon system configuration (longitudinal or longitudinal/lateral control and used gap), different sensors such as cameras, corner radars, lidars and V2I communication can expand the sensor set-up. Today`s research systems showed platooning with gaps up to 5 m for highway use cases [13].

2.3.2 Legal framework

The operation of truck platoons on European roads needs special permits. This results primarily from the general missing framework for the operation of automated vehicles on European roads and secondly on the short gaps platoon systems use, that infringed safety distances and are therefore not allowed today (Art. 13 of the Vienna Convention, implemented individually by national regulators). For instance, in Germany, trucks that weigh more than 3.5 t, must follow other vehicles with a distance of at least 50 m for speeds higher than 50 km/h, while the distance between trucks while “platooning” is 10m or even below at even higher speeds on the highway. Furthermore, the equipment used has to fit the definitions of Art. 39 of the Vienna Convention or has to be added in Annex 5. Like for most use cases of CAD the questions regarding liability, insurance and type approval arise. Regarding the liability this applies to the leading driver in particular, as he takes over responsibility for other goods and lives. Furthermore, protective measures have to be considered legally and implemented technically to prevent misuse (e.g. leading truck driving down a bridge).

2.3.3 Acceptance

The acceptance of platoon systems is insufficiently investigated. One known investigation was done in the German platoon project “Konvoi”, which was funded by the BMWi in Germany from 09/2005 to 11/2009. The investigation was focused on the overall system acceptance and on the usage. Legal questions and business aspects were not covered with the truck drivers. In this project a three-step investigation with a pre-acceptance, an acceptance and a post-acceptance phase was performed. In the pre-acceptance phase the acceptance of truck drivers, freight forwarders and other traffic participants was surveyed by the usage of group discussions and recorded video tapes. In the acceptance phase truck drivers and other traffic participants had the chance to experience the platoon system in a driving simulator. Within the post-acceptance phase truck drivers, freight forwarders and other traffic participants could experience the platoon system on a test track. In the acceptance phase there were 54.04% positive answers. Accordingly, the positive attitude of the truck drivers has been rising during the acceptance process [15].

2.4 "The car as digital experience center"

Since the basis for a "car as digital experience center" is a fully functional level 4 vehicle, this is probably the most challenging business case and therefore the business case with the longest time frame till deployment.

2.4.1 Technical

To ensure a fully functional level 4 vehicle, there are many challenges to overcome. Beside the software modules of automated driving like perception, localization, behavior generation, trajectory planning and controls, the hardware must be redundant and fail-operational to be still functional even after a system failure.

The design, quality and maturity of the function are directly linked to the availability of the function and thereby to the acceptance after deployment.

The state of the art of the technical and legal layer as well as a brief summary of acceptance studies of automated driving with focus on level 4 functions, are all compiled in deliverable 3.2 "Report on the state of the art of connected and automated driving in Europe" and are not repeated here in detail.

Overall it can be stated that several sensor types are available each having advantages (e.g. high accuracy in distance measurement, classification etc.) and disadvantages (e.g. dependent on weather conditions, costs etc.) and therefore they have to be fused to enhance the overall system performance. The architecture for information flow and processing can be decentralized or centralized. Today many vehicles have decentralized architectures with different ECUs throughout the vehicle. Each ECU is responsible for a specific task. It is expected that a centralized processing unit is required in the future. This highly performant central processing unit, which is capable of processing a huge amount of data in real-time while considering safety standards like functional safety requirements according to ISO26262 [16] is able to process raw sensor information and fuse these into a generic environment model.

Based on this environment model, a maneuver and a suitable trajectory has to be chosen from several possible maneuvers available at a time and this varies tremendously dependent on the use case and/or the application field. It is nearly impossible to know all situations in advance and describe them in a deterministic manner. However, a solution must be found, which can be comprehensible. This disregards the decision in a dilemma situation, which is described in [17]. Dilemma situations must be considered on top of the "normal driving"-situations.

At the end of the automated driving (mostly software) chain, the controls and the execution of the planned behavior comes into place and this requires fail-operational actuators with all their implications on the E/E architecture and other components of the vehicle. These fail-operational actuators are currently under development and first product announcements are made [18][19] and need to be integrated in the overall vehicle architecture to satisfy the needs of redundancy and fail-operational actuators.

As soon as all these challenges are solved, new interior concepts or completely new vehicle concepts can be designed and deployed with level 4 functionality to adapt to the needs of the customers. These customers can be ride-sharing or ride-hailing providers as well as stakeholders from the public domain or private customers. The possibilities to create new business models on this basis is nearly unlimited.

2.4.2 Legal framework

Level 4 vehicles are currently legally not allowed to be operated on public roads, whether according to the Vienna Convention or national regulations. So far Level 4 vehicles can only be tested within test beds. These test beds are based on national regulations and restricted to certain roads or areas like the A9 in Germany or the DriveME project in Gothenborg, Sweden. [20][21] This is where the legislation in Europe is one step behind the USA where large tests on public roads through companies like WAYMO [22] are performed under a legislation that allows autonomous cars on public roads.[23] Therefore, it is necessary to include at least the possibility of extended test fields in the Vienna Convention to accelerate the development and deployment of CAD and ultimately the inclusion of autonomous cars on public roads in the Vienna Convention and national regulations. The state of the art of legislation within Europe and its countries is also covered in deliverable 3.2 “Report on the state of the art of connected and automated driving in Europe”.

2.4.3 Acceptance

Acceptance studies in real world traffic have not been performed so far. Currently there are still safety drivers onboard, which turn the system into Level 2 vehicles.
Acceptance studies in simulators are being performed by various companies. Results are expected to be published in the near future.

3 Conclusion

Based on the suggested business models from deliverable D4.2 “Report on novel business models”, an evaluation of the technical and legal status to deploy these ideas has been conducted and the acceptance of the users for new business models were also examined.

The variety of the proposed business models is broad and difficult to compare. Starting with a (near) series product (eCall) and ending with a business case, which has neither the technical solution in place nor the legal framework, the paths towards deployment are totally different.

All afore mentioned business cases are valid and worth to be considered for the future and each case has its own value for the society or the end users.

On the path towards level 4 or even level 5 systems, there are so many dependencies or interactions between each module from the technical side, and there is also the lack of a legislation, which is able to advise or specify requirements for the operation of automated driving, that it is nearly impossible to sketch one single path. The need for a suitable legislation on the one hand, but also cost efficient and robust sensor technologies, efficient automotive computing power and an approval concept (simulation vs. real-driving testing) to deploy automated driving on a big scale, are still the reasons why a lot of research and development effort must be spent for these developments.

In addition, there are still some major disconnects between the targeted user and the way the industry and other stakeholder see the development. Especially when it comes to security, privacy and liability. With user acceptance being a key for market uptake and ultimately the success of CAD, there have to be new ways to integrate users besides some surveys. This also applies to governments and other regulatory bodies.

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