White Paper

Monetizing automotive data

A perspective on how data drives revenues and growth in future automotive business models

Christian Koehler – Strategy Engineers GmbH
Ulf König – Strategy Engineers GmbH
Ingo Olschewski – fka Forschungsgesellschaft Kraftfahrwesen mbH, Aachen
Christian Burkard – fka Forschungsgesellschaft Kraftfahrwesen mbH, Aachen

Digitalization of vehicles

Digitalization is one of the universal trends in our world. Digital devices have become ubiquitous and cyber-physical systems are widespread in many sectors. Enormous amounts of data are created, transferred and processed every day.

Digitalization has reached the automotive world and modern vehicles generate and utilize data in never seen before magnitudes. Today's vehicles are not only equipped with an array of sensors to collect and monitor their own state and their surroundings, but have also access to a multitude of other data sources beyond the physical vehicle's scope. Fully connected vehicles of the future will further extend traditional information boundaries by utilizing digital data from a wider range of sources.

Those vehicles will connect to a complete eco-system of automotive data, generated by other road users (e.g. pedestrians, cyclists and vehicle passengers) and the digital devices they carry, the increasingly digitally controlled infrastructure (e.g. traffic lights, bridges, parking spaces), and data provided through internet services and other servers. Exhibit 1 gives an overview of the automotive eco-system and the data sources in it.

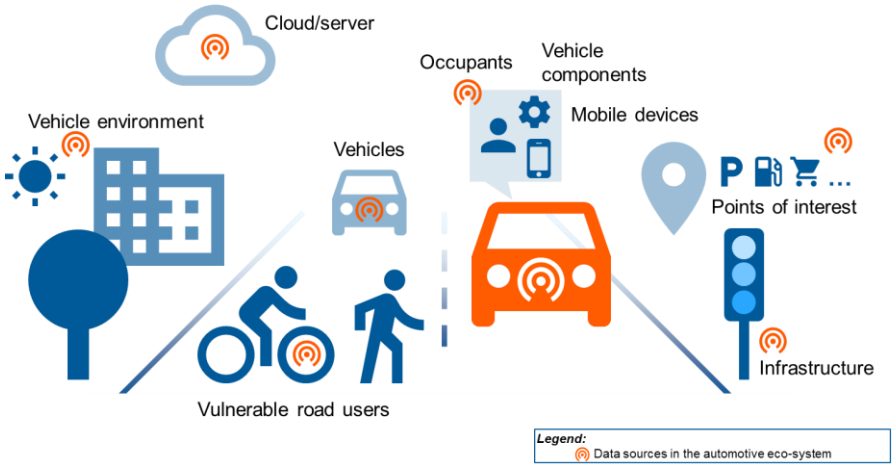

Exhibit 1: Data sources in the automotive eco system

Despite the already existing abundance of data in the automotive eco-system, current technology trends, such as active safety, connectivity and autonomous driving further reinforce and require digitalization beyond current levels. Today's vehicles create, process and exchange approximately 50 GB of data per day on their internal bus network. Advanced functions will require a larger number of sensors, additional routines and increasing vehicle-internal networking, leading to an exponential growth of vehicle-internal data volume. It is estimated that the amount of on-board generated and utilized data will increase 80-fold to over 4,000 GB until 2020. (Exhibit 2)

Compared to the amount of data created within the system boundaries of our vehicles, the amount of data exchanged between vehicles and their environment today is miniscule (about 1 MB/day). Vehicles fully connected to other road users, infrastructure and the internet are expected to increase the amount of transferred data

by a factor of 20. As soon as connected vehicles will also be able to drive autonomously, the amount of data transmitted is expected to increase exponentially. Peak transmission volumes of ~16 GB per day must be considered realistic, provided that comprehensive data sets (e.g. a complex vehicle environment and infrastructure model) are exchanged at high frequencies[1].

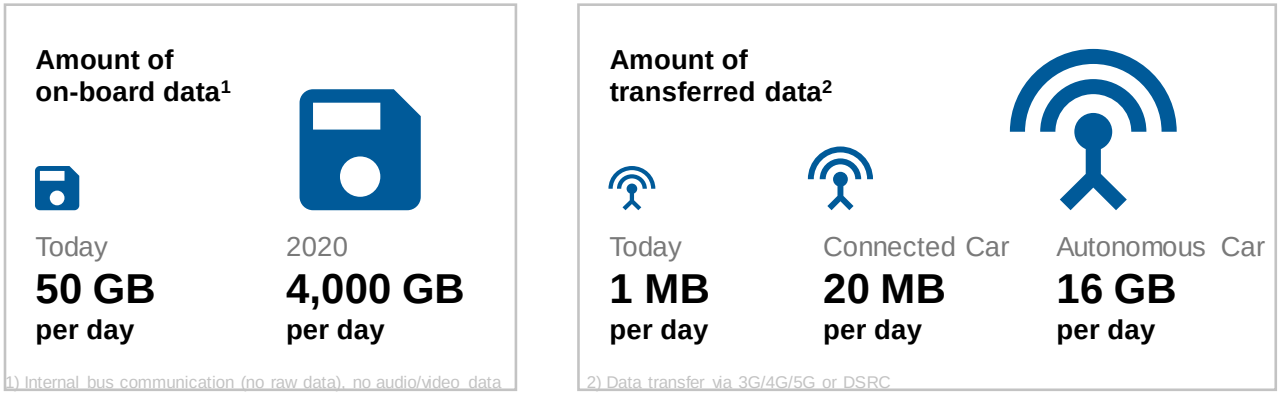

Exhibit 2: Increase of digital automotive data

The rapidly increasing amount and access to automotive data has attracted the attention of both established automotive and non-automotive companies, which seek economic potential from the newly available data pool. While the automotive industry is just starting to capitalize on the economic value of automotive data, so that this value is therefore difficult to assess credibly, other industries have proven that viable businesses can be built on data.

Prominent examples for successful data-driven business models are pure data companies (e.g. Google, $79 billion or facebook $27 billion in revenues), digital services (e.g. Apple's App Store, $28 billion) or data-based service platforms (e.g. Uber, $7 billion or AirBnB, $2 billion). However, these remarkable examples of successful data-driven business models are not directly translatable to the automotive industry. This is largely due to the fact that most of the examples given above generate their revenues from rather traditional advertisement. At least from today's vantage point, it is doubtful, that advertisement as it is presented in facebook or Google will find its way into the vehicles of tomorrow. It is more likely that new and yet unknown mechanisms and business models will need to be devised to make data-driven businesses applicable to the automotive industry.

Essential to the development of those new business models is openness with and access to data. In contrast to e.g. smartphones and computers, which have become open platforms for third party service offerings through app-stores and publicly available APIs, vehicles are traditionally designed as closed systems, offering only limited access to the data generated or used within it. The willingness of OEMs to grant a wider group of parties access to their vehicles' data than today is therefore key to unlocking the economic value of automotive data.

[1] The wireless transmission standards required for such data quantities (e.g. 5G or ITS-G5) are currently being developed and expected to be in place in time to support this growth of data transmitted in the automotive eco-systems

However, indications for a paradigm shift can be observed in the industry. For one, standardization bodies are currently developing a common standard for vehicle data access (ISO 20078), the VDA released a statement to grant access to vehicle data and specific OEMs (e.g. BMW) have recently announced plans to introduce data platforms for external service providers (e.g. BMW CarData). The fact that selected OEMs (e.g. Tesla) have demonstrated how revenues can be generated from data-driven value-added services by using vehicle and passenger generated data to further develop their vehicles' functionality, has also helped to put digital data and services on the automotive industry's agenda.

In order to grasp potential revenue sources and develop according business models for the automotive context, the vast and diverse set of automotive data must be structured and classified. The following chapters will provide such a classification and segmentation of data, derive a value chain and identify potential business models based on it. Ultimately, generic strategies for today's automotive players and prospective new entrants are discussed.

Segmentation and classification of automotive data

As discussed in the previous chapter, key automotive technology trends will drive increased data generation and availability in the automotive eco-system. The multitude of different sensors and other data sources will produce a vast amount of different types of data.

Consider a data point describing the current interior temperature of the vehicle compared to information on the estimated time of arrival at a set destination. This simple comparison quickly reveals the significant span entailing automotive data. It therefore appears prudent to first define “automotive data”.

To that end, we propose 3 dimensions (compare Exhibit 3) for segmenting automotive data, which are:

» Reference Object – What does the data describe?

» Aggregation level – How much has the data been processed?

» Timeliness – Is the data describing past, present or future states?

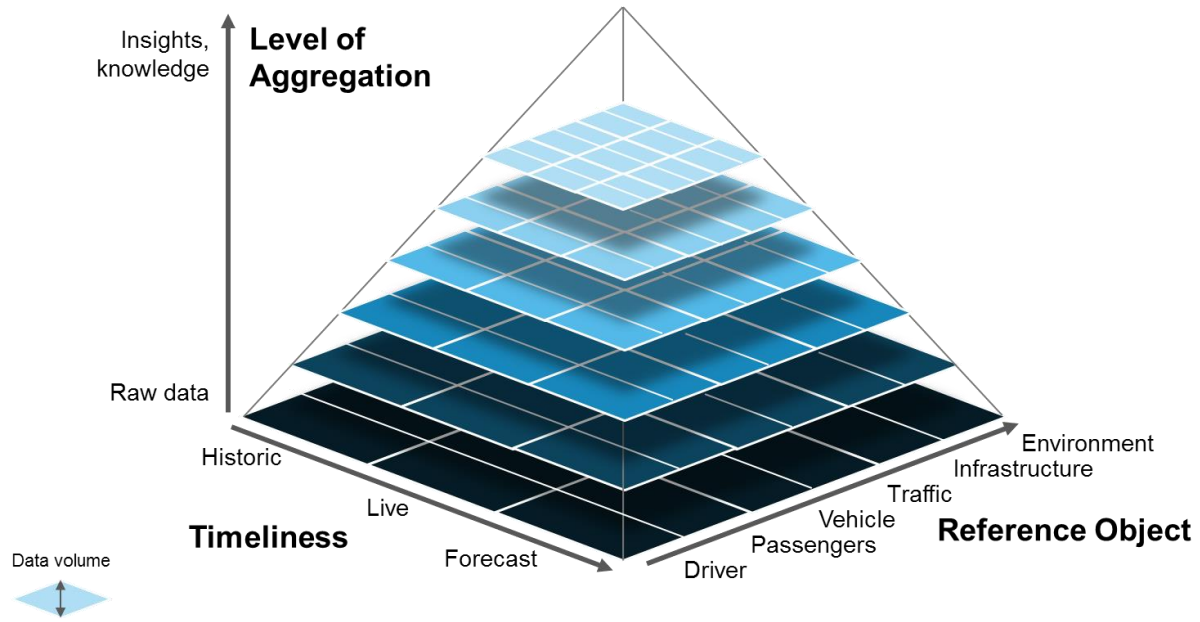

Exhibit 3: Automotive data segmentation pyramid

Any automotive data element can be classified per this segmentation. To illustrate the concept, please consider the following:

Starting with the rotational speed of a wheel – this would be considered a *raw* and *live data* point, describing a part of the *vehicle*. If the wheel speeds from all wheels are considered together and aggregated with speed information from the GPS module, a quite accurate information about the vehicle’s current travelling speed

can be generated. This data point would then be considered *aggregated* and *live data* regarding the *vehicle*.

Furthermore, consider a situation in which the wheel speeds and the GPS speed differ largely and further information from the yaw sensor indicates a large yaw angle. When this information is then compared with values considered as “normal”, an *interpreted* and *live data* point regarding the *vehicle* is created. Simply put, such an interpreted set of data could indicate that the vehicle is skidding and might be out of the driver’s control.

If this information is now further coupled with information about the outside temperature and optical sensors which survey the road surface indicate ice on the road at the same time, it could be derived that the vehicle is skidding due to ice on the road. This is considered a *live insight* regarding the *vehicle*, *infrastructure* (the road) and *environment* (the weather). If those insights are collected and stored, they become a *historic data* set. This data set can be further enhanced with GPS location data, extended across multiple vehicles and be made to include not only temperature and weather information but also time and date. From this historic data, insights can be derived and provided to other road users in form of a *forecast*. It would state that this particular stretch of road, under certain weather conditions at certain times is prone to icing and should therefore be approached with extreme caution.

This consideration does not only illustrate the usefulness of the suggested framework to categorize automotive data points. It also serves as a starting point to assess the economic value of automotive data. While it is difficult to assign a precise monetary value to a data point that is currently not traded on any market, the introduced segmentation allows for a generic data valuation along the dimensions of the segmentation pyramid (compare Exhibit 3).

Generally, data points at the top rear of the pyramid (insights/forecasts) will be considered more valuable than data points to the front bottom of the pyramid (raw/historic). In that, it has yet to be seen whether historic or live data will be considered more valuable going forward – arguments can be made for both. The same holds true for the valuation of different reference objects. At the current stage one would be hard-pressed to argue how data on different reference objects should be valued without a market in which data are traded.

The automotive data value chain

Similar to a value chain for production goods and services, we expect an automotive data value chain to emerge which comprises the necessary activities for commercial usage of data. This value chain describes the necessary steps from raw data to an application of data in form of a service.

Exhibit 4 depicts a generic value chain for automotive data. It consists of 6 distinct value creation steps and incorporates 2 platforms with which data and services are made available to a specific set of stakeholders. Similar to value chains for tangible goods and services, each processing step within the value chain increases the value of the underlying data.

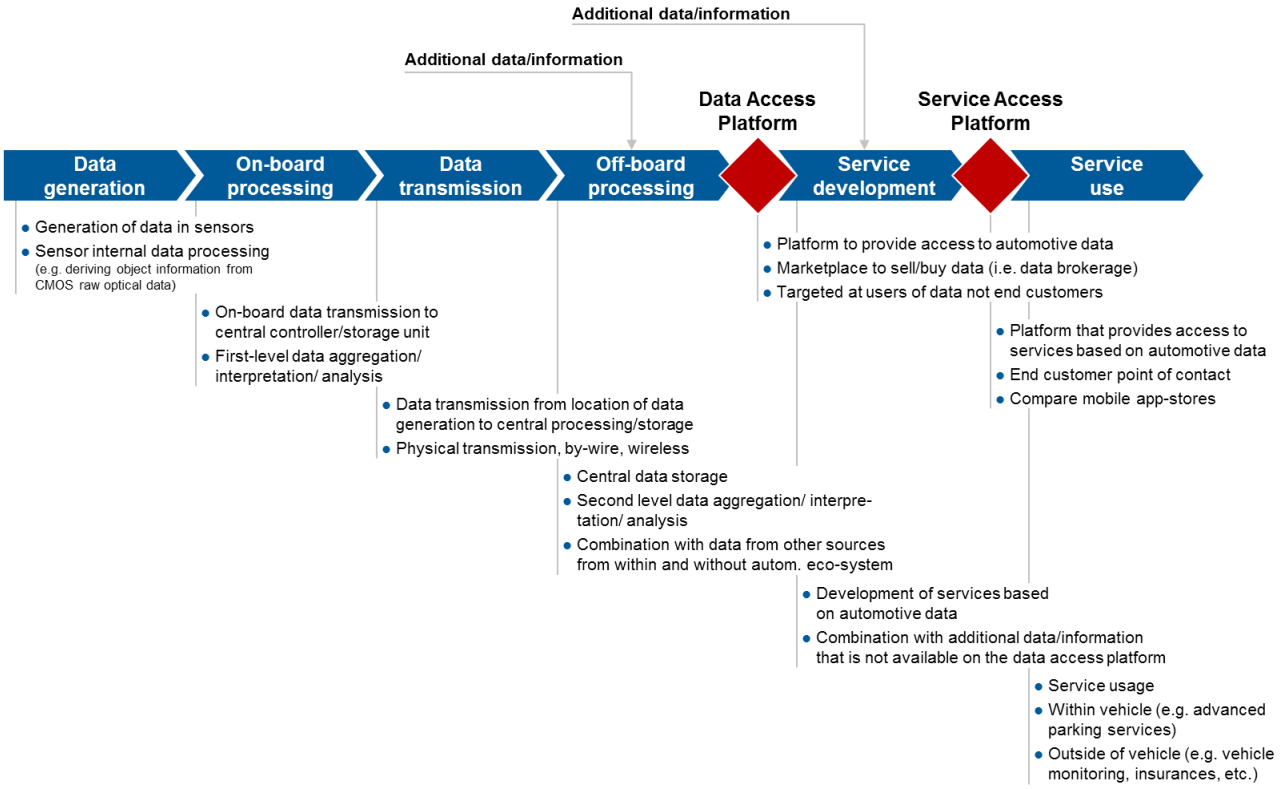

Exhibit 4: The generic automotive data value chain

The generation of raw data marks the beginning of the automotive data value chain[2]. Subsequent to a sensor internal processing, these data are transmitted to electronic control units for further vehicle on-board processing. As a prerequisite for a usage of data beyond the physical vehicle systems, a transmission of data to a central processing and storage entity is required, which will most likely take place via WLAN or mobile communication connection.

[2] Please note: For sake of simplicity, the value chain is described based on data generated within one single vehicle. Naturally, data generation can also occur outside of a vehicle (e.g. within an infrastructure object such as traffic lights or else). The generic value chain applies to data generated within any object of the automotive eco-system

The off-board processing of data on servers is a key value chain step for generating economic value out of vehicle-related data. Further data analytics and evaluations can be performed due to a much larger amount of available data sources and higher processing performance. Furthermore, external data from other sources, e.g. infrastructure data, can be combined in this step. However, the access to data is restricted to OEMs, thereby limiting the potential to capture economic value.

Providing access to automotive data to further parties therefore represents a key element for the monetization of those data. As it stands today, OEMs and some third parties have begun to establish data access platforms, which collect data and provide it to downstream processes. Publicly accessible data access platforms which are run by OEMs such as PSA's P4D[3] or BMW's CarData[4] exist, but are rather limited. Typically, those platforms offer selected data from a single OEM and allow a well-defined set of manipulations on those data. In contrast to OEMs, third parties such as INRIX or TomTom can collect data from a wider range of sources and offer the collected data publicly to a wider range of potential customers.

In contrast to the aforementioned data access platforms, this paper defines "data access platforms" as marketplaces in a wider sense. In that sense, a data access platform represents a marketplace in which data from potentially all data sources in the automotive eco-system is made available and being exchanged to potentially any party who is interested in those data.

While data can also be monetized along other steps of the value chain, the data access platform acts as the central market place in which prices are formed and value is attributed to different types and qualities of data. As economic value goes unused if data is not made available to a broader circle of potential buyers, it is expected that data access platforms that start out "OEM only" will eventually open-up to a wider audience.

By means of the described access platform, automotive data is made available to interested parties, which can then develop their services on those data as a next step in the value chain. In that step, data from the access platform is used to build a service offering appealing to an end customer[5]. The developed services are subsequently made available to the service users via a service access platform. Similar to the data access platform, this platform also represents a marketplace on which service developers/providers offer their solutions to end customers. Although the data access platform and the service access platform will potentially be hosted on the same server or at least be operated by the same market player, both platforms serve different purposes and different audiences.

The final step in the automotive data value chain is the actual use of the service (e.g. advanced parking services) in a vehicle or at any other place. It is in this step in which monetization of automotive data is most obvious. Nonetheless, data can be monetized in any of the described steps of the value chain.

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[3] Further information on PSA's P4D is available on: https://developer.psa-peugeot-citroen.com/inc/

[4] Further information on BMW CarData is available on: https://aos.bmwgroup.com/apps/otp-public

[5] Please note: For sake of simplicity, it is assumed that the end customer is within the automotive eco-system and likely the driver/occupant of a vehicle. However, it is not far-fetched to assume that there can be services developed for end customers apart from vehicle users (e.g. city planners, insurances, etc.) and even beyond the automotive eco-system

Monetizing data along the value chain

When it comes to monetizing automotive data, 8 distinct business model archetypes can be identified (compare Exhibit 5). These business model archetypes generally follow the structure of the value chain and are discussed in the following.

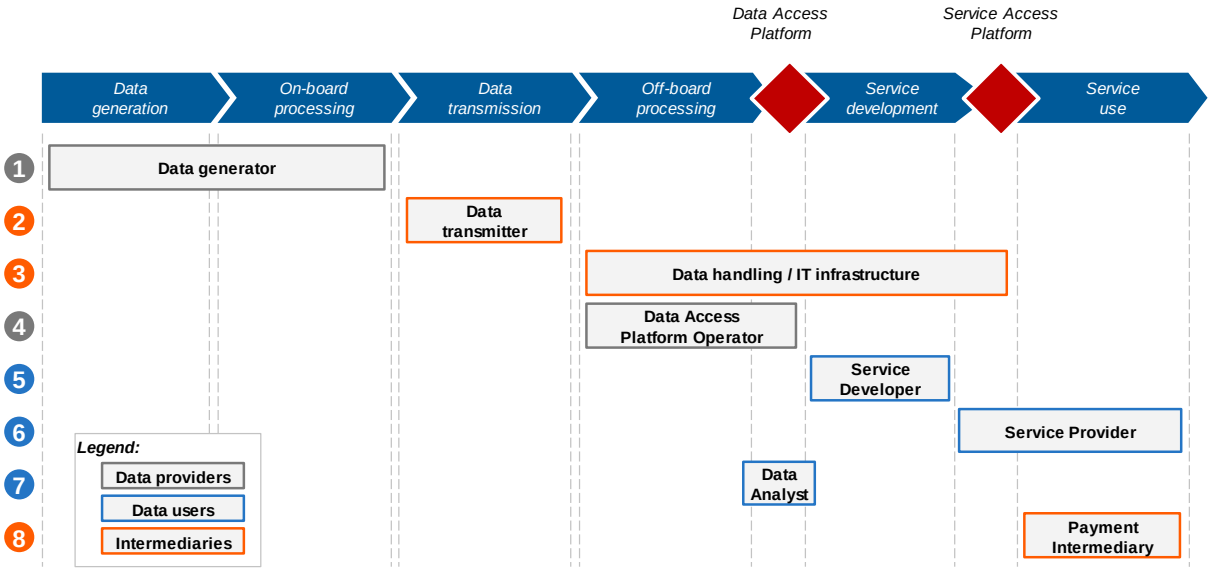

Exhibit 5: Business model archetypes along the value chain

The **Data Generator** represents the player in the very first step of the value chain, generating or collecting data close to its source (e.g. within the vehicle). Today, OEMs or large Tier1 suppliers can act as an example of the data generator business model, selling the data produced during the operation of the vehicles to other parties. However, the data generator business model is not limited to suppliers or OEMs but is valid for other players as well. Google for instance already acts as a data generator for traffic data by collecting mobile phone and movement data via Android devices and selling them to other parties. Another example are parking operators selling their data on available parking spots to developers of parking apps or navigation systems.

The **Data Transmitter** monetizes on breaching the physical gap between the location of data generation and its central storage. Natural candidates for this role are telecommunication companies such as Deutsche Telekom or Vodafone. However, OEMs such as Volkswagen have announced plans to equip their vehicles with WLAN-based communication technologies, thereby also reducing their dependence from mobile network operators for data transmission.

The processing of digital data along the value chain requires not only data transmission infrastructure. At minimum, a **data handling and IT infrastructure** needs to be in place to collect, store and provide access to data, which offers another way to monetize on automotive data. The data handler and IT infrastructure provider establishes performant server architectures and monetizes them on the back of e.g. provided storage capacity. This business model is fully in line with services offered today by e.g. IBM, Amazon Web Services, or OEM internal server operators.

The **data access platform operator** collects data from generators and/or transmitters and makes it available on an established IT infrastructure. It defines the design of the access platform and charges a fee for the transactions on the platform. Companies as INRIX, can act as examples for platform operators today. Some OEMs (e.g. Peugeot with the PG4D) have started to adventure into this role but have yet to monetize on it. While at this point, it is too early to judge, whether the prime revenue stream will be from charging parties that want to buy or parties that want to sell data, it is expected that access platforms will need to find a way to get reimbursed for their costs, be it through advertisement or any other form.

With access to automotive data, **service developers** can make use of the information made available to develop compelling services for users within and beyond the automotive eco-system. Natural candidates for this role are e.g. app developers for smart devices or software development companies. But also OEMs or other traditional players in the eco-system such as parking providers could take this role. Essential to this business model is that the service developer is reimbursed for the development of the service (e.g. the developed app) and is not necessarily providing the service to the end customer.

This is the role of the **service provider**, whose business model is not developing a service, but offering a service to an end customer. The business model builds around usage fees raised for the end customer, while the service developer gets reimbursed from the service provider. The relationship between a vehicle driver (i.e. the end customer or service user), an OEM (the service provider) and a software development company (the service developer) illustrates the concept.

With data readily available through platforms, **data analysts are expected to emerge** with a distinct business model. Those players would not use the access to data to build services on them, but would instead analyse the available data and monetize the insights generated from those. This business model is comparable to today's well known automotive data analysts such as IHS Global Insight, JD Power, or Frost&Sullivan.

At the end of the value chain, service usage poses another business opportunity for **payment intermediaries**, which handle the billing and payment of the end customer for using automotive data based services. OEMs which plan to offer additional data-based services in their vehicles face the added challenge (in contrast to e.g. Google) of their limited experience in managing usage based payment schemes, as their business model is based on one-time sales. Consequently, their internal processes and structures are geared towards one-time sales and not set up (yet) to effectively and efficiently handle usage-based payment. Payment intermediaries from other industries (e.g. telecommunications) on the other hand, do have this experience and may enter the playing field offering their services to either the service providers or end users. These dynamics are especially transparent whenever micro-payments are involved, for instance paying a parking ticket via the monthly mobile phone bill.

When considering the above described business model archetypes, three groups of archetypes emerge according to the nature of their offering (compare Exhibit 5). Data generators and platform operators can be clustered to **data providers.** Service developer, service provider and data analysts on the other hand can be described as **data users.** The data transmitter, data handling/IT infrastructure and payment intermediaries all provide **intermediary** services.

Exhibit 6 drafts the concept of an automotive data access platform, which brings together different players on a common platform. The concept envisages the integration of heterogeneous types of vehicle and traffic related data, which are provided by various parties, on a joint data platform. These data are offered for sale to potential data users, e.g. suppliers, insurances or 3rd parties. Besides data storage, the platform supplies basic services like data analytics, contract arrangement and payment services. Compared to other data platforms, both data provider and data users benefit from a large number of market participants and available data. For data providers, a larger number of potential users implies a larger customer base and higher revenues. For data users, the willingness to develop a data-based service and the quality of this service increases with the amount of available data.

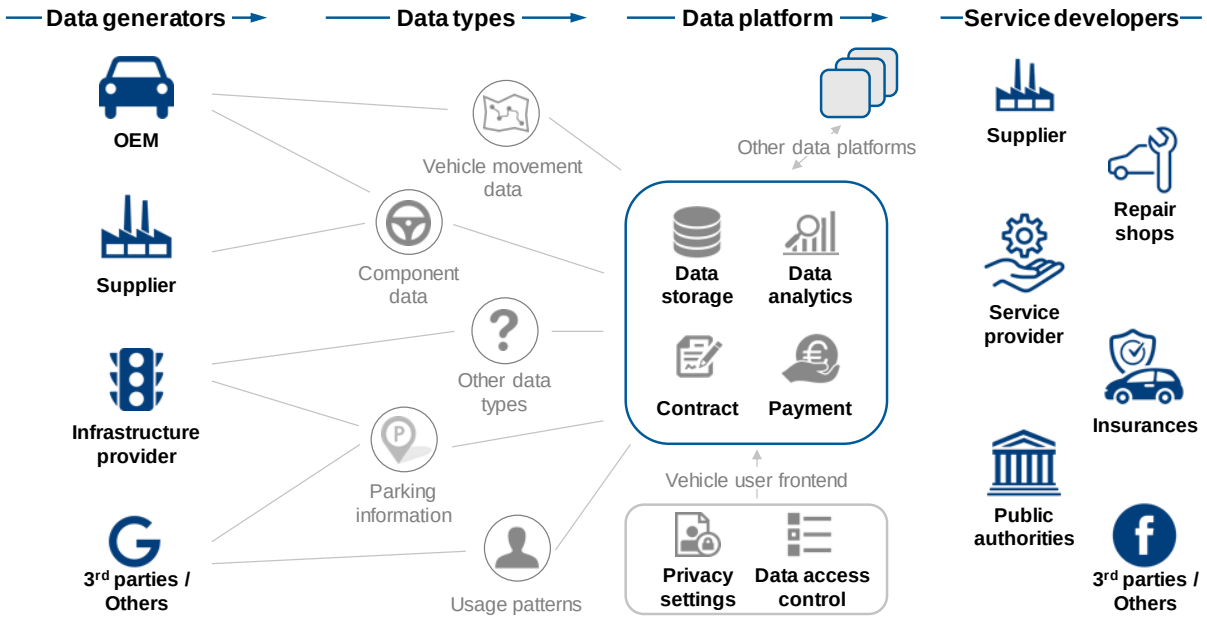

Exhibit 6: Concept of an automotive data access platform

Since the benefit for all parties involved directly depends on the amount and diversity of accessible data, the access platform will be subject to strong network effects. Due to this effect, a coexistence of multiple data platforms (e.g. proprietary OEM platforms or supplier platforms) seems to be unlikely. Therefore, a consolidation of data platforms can be expected as long as a critical mass of market participants and stored data has not been reached.

Platforms will likely set (quasi)standards for data input into the market place as well as data formats available for purchase (i.e. data output). These platforms will shape the recorded data and its transmission formats as well as necessary preprocessing steps upstream. Likewise, they will also define the boundaries of potential use cases of the data downstream.

By defining data formats, the platforms will also be crucial to providing data anonymity, data validation, data protection, and data security. They will further be the basis for any B2B legal considerations and contract management within the automotive data value chain.

Implications for automotive players – how to make money with data and secure sustainable positions

The automotive data value chain is not emerging in a void and has not gone unnoticed by today's automotive and digital players. OEMs, suppliers but also other players such as Apple and Google are eagerly trying to position themselves at certain steps of the value chain in order to secure their share of the potential revenue pool created by automotive data. (Exhibit 7)

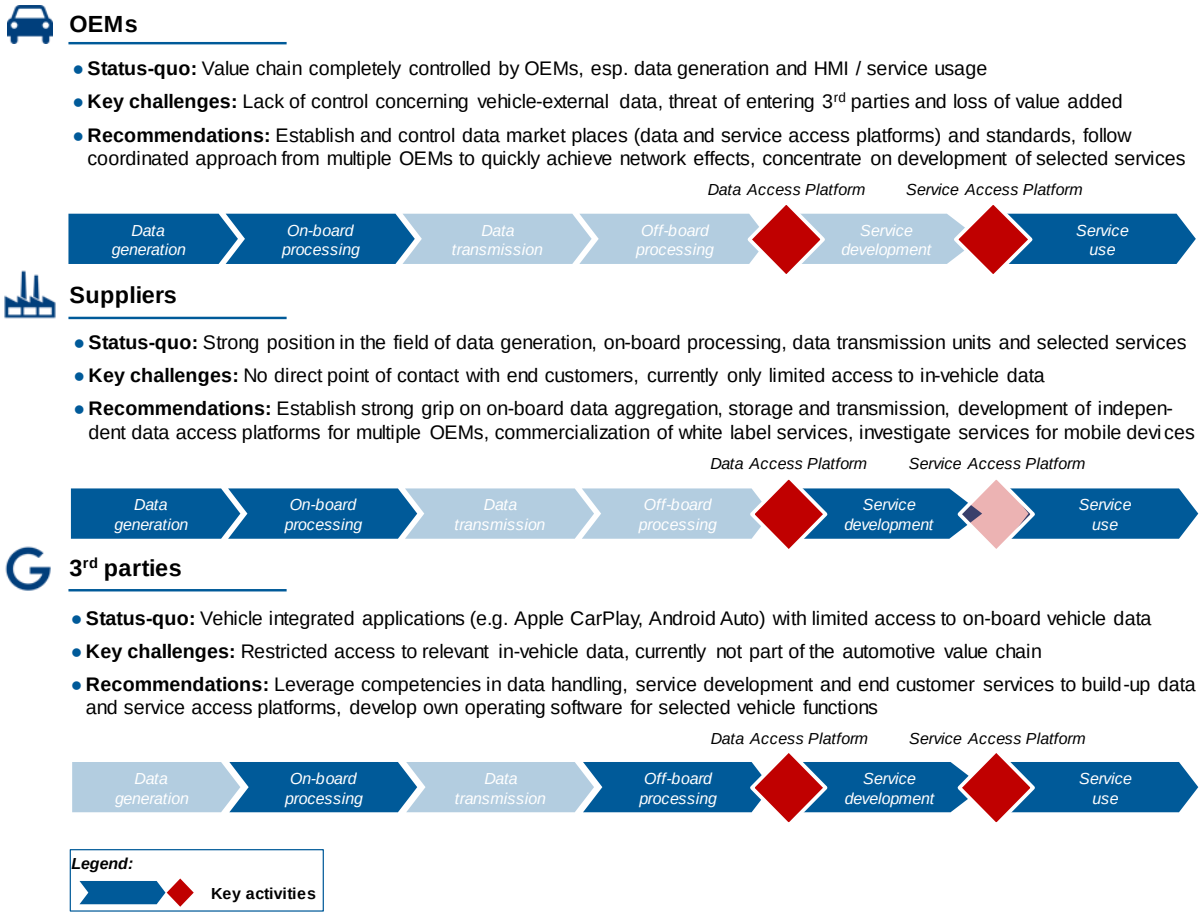

Exhibit 7: Implications for OEMs, suppliers and 3rd parties within the automotive data value chain

However, there is no "one-fits-all" strategy for the different players when it comes to gaining a competitive advantage in automotive data. Based on their current business and expertise, **automotive OEMs** are in a strong starting position. The OEMs' strength results from their control over the data value chain as described above. As of today, OEMs are in control of not only the starting point of the value chain (the data generation in vehicle) but arguably more important, the endpoint of the value chain (the information displayed and the way of communication with the vehicle occupants). OEMs today can control which data is generated, stored and transmitted by their vehicles, but they can also define which services are offered to the occupants of the vehicle

However, the OEMs strong position does not extend beyond the vehicles. On the contrary, the vehicle space which the OEM controls is being invaded by other players. While the OEMs still control data generated, stored and managed within their hardware, they do not control data generated and utilized by other sources or devices such as smartphones.

Consequently, OEMs which want to successfully capitalize on automotive data need to control the end customer interaction. Here they face a substantial threat of entering 3rd parties such as Google or Apple, who themselves are well positioned towards the customer through the mobile devices that almost everybody now carries. To that end, OEMs also need to fend off payment intermediaries from entering the vehicle by establishing their own capabilities of charging customers for services.

OEMs should extend their hold on the automotive value chain by establishing themselves as automotive data market place operators (be it data access or service access platform). As discussed in the previous chapters, the emerging market places will be pivotal for the whole value chain – upstream and downstream. If OEMs allow other players to shape this central element of the value chain, they run themselves the risk to become degraded to mere hardware provides, while the value creation is monetized by others. However, since data market places are subject to strong network effects with clear benefits for large market places, a coordinated approach from multiple OEMs is highly promising.

Through the creation of automotive data market places, OEMs will remain in control and can actively lead the definition of industry standards for data transmission, validation and payment, which in-turn allows them to more easily keep control of on-board data versus large Tier1s such as Bosch or Continental.

When it comes to developing actual end-customer services, OEMs should move cautiously. OEMs will likely have to drive the initial development of basic services to cater to the most obvious needs of their vehicle users. Furthermore, OEMs should also trigger the development of services with high strategic relevance or offering a strong competitive differentiation, for example pre-emptive safety functions. Through the intelligent combination of historic and live data (compare Exhibit 3) from vehicle sensors, infrastructure and road conditions as well as individual driver behaviour data, insights can be generated which allow a detection and forecast of critical situations. Based on those predictions, pre-emptive warnings and avoidance measures can be initiated. Additionally, OEMs can also adapt the operating strategies and the functionality of vehicle systems to minimize risk of accidents at an early stage. Hence, OEMs that are able to offer such functions to their customers can not only differentiate their offering regarding occupant protection but also increase traffic safety in general.

However, OEMs should not give in to the temptation to try to develop the next killer application for automotive. They neither have the competence nor the speed to effectively satisfy the fast-paced demand for end-user applications. OEMs may look to smartphone OEMs and adapt a similar approach. Mobile phone producers such as Samsung and Huawei develop basic apps to ensure a specific OEM user interface, but open their platform (through Google's Android) for anyone who considers their app worthy of the end-users' interest. The smart device industry and their app stores can act as a role model in regards to how to create an eco-system and keeping control over the end-user point of contact/sale while capitalizing on the many creative and smart heads that develop applications and services.

Compared to OEMs, **automotive suppliers** are in a less advantageous position today. However, they can build on a set of core strengths in regards to automotive data themselves.

Automotive suppliers are often not only deeply involved in data generation, its on-board transmission, data analysis and storage, but can also act across multiple OEMs. In contrast to OEMs, large suppliers are well positioned to develop automotive data solutions (be it transmission protocols, market places or services), that appeal to multiple OEMs at the same time. Based on this advantage, automotive suppliers should aim to establish a strong grip on on-board data aggregation, storage and transmission, e.g. through central control units.

In turn, suppliers are also well advised to build data access platforms, again capitalizing on the advantage that an independent supplier market place holds greater appeal to a wider audience than a single-OEM market place. INRIX for example is an often-used example of a supplier-led market place for automotive data, other large Tier1s will soon announce their respective efforts to that end.

As suppliers do not have the end-user point of contact today, they face difficulties with generating awareness and volumes, both essential when it comes to providing end customer services. In case suppliers target activities at the end of the automotive data value chain, they are best advice to make use of white label solutions which are customizable by OEMs or other service provides. This also makes their solutions service-provider independent which in turn increases potential volumes of the service.

Suppliers have another route to explore compared to OEMs. As suppliers are not tied to the vehicle as such, they might consider to circumvent the OEMs and directly approach the service end customer via their mobile devices. Suppliers, that are able to develop superior end-customer offerings (compare e.g. GoogleMaps navigation) based on their knowledge of available automotive data, can (via smart devices) monetize directly with the user and can cut the OEM as middle-man.

Beyond traditional automotive market players, such as OEMs and suppliers, new **3rd parties such as Google and Apple** push into the market. They can leverage their basic skills in data handling and services development, but more importantly, can transfer their expertise in developing market places and end-user app stores. They have already established all administrative components that come with that kind of platforms such as security, legal and payment services. Like the suppliers, they can act cross-OEM and already offer today white label solutions for in-vehicle integration (e.g. Apple CarPlay or Google's Android Auto) with a limited access to on-board vehicle data. Furthermore, they already have established the end-customer point of contact through smart devices which is arguably stronger than the OEMs point of contact through the vehicle.

Especially Google and Apple are in a strong position to enlarge the scope of their current in-vehicle integration software towards developing true automotive operating systems (compare Android or iOS on smart devices). While this is admittedly neither an easy nor quickly achieved step, both companies are already gaining experience in that domain through their autonomous vehicle projects. The conditions for Google and Apple for creating an automotive data marketplace could even improve significantly, as soon as one OEM would integrate their system as a USP feature.

Apart from the large and visible 3rd parties such as Google and Apple, smaller, more **specialized 3rd parties** such as service developers or payment processers have the potential to leave their impression on the value chain as well. Especially service developers, who specialize in developing applications for the automotive eco-system have the chance to establish themselves as early movers by successfully partnering with key players along the value chain, building on the service and software development capabilities that especially traditional players lack. In turn, payment intermediaries can find their niche with traditional players lacking the abilities to effectively and efficiently transition from a “one-stop-payment” to continuous billing and payment schemes.

In summary, the automotive industry is just starting to unlock the revenue potential automotive data is expected to yield. While no credible valuation can be given for this revenue potential as of now, a simple comparison to other industries indicates the significant business potential. A distinct value chain for automotive data is currently emerging, allowing incumbents and new entrants in the automotive industry to acquire their positions and build business models on their distinct capabilities around data.

Especially OEMs face significant urgency to adapt their strategies if they want to avoid losing their grip on the value chain. At the same time, this poses an opportunity for other players such as 3rd parties to enter the industry and claim a share of the data-based revenues.

The authors

Christian Koehler

Christian Koehler is a partner with Strategy Engineers and has more than 20 years of experience as management consultant and in the automotive industry. He is focused on product and technology strategies, product development and Asian markets in the automotive, heavy truck and supplier industry.

E-mail: ck@strategyengineers.com

Ulf König

Ulf Koenig is a Principal with Strategy Engineers. As a studied mechanical engineer he brings 10 years of professional experience at automotive OEMs and major suppliers globally. He is focused on product development, technology strategies, as well as cost optimization in the automotive, off-high way as well as the machine building industry.

E-mail: uk@strategyengineers.com

Ingo Olschewski

Ingo Olschewski is Senior Manager at fka. With a background in Business Administration, he has been working as an automotive consultant since 2005. His focus is on product portfolio strategies for OEMs and suppliers as well as market forecasts in the field of Automated Vehicles and Electric Mobility.

E-mail: ingo.olschewski@fka.de

Christian Burkard

Christian Burkard is Senior Consultant at fka. With a background in Business Administration & Engineering, he has been working as an automotive consultant since 2010. His focus is on technology consulting and innovation management projects in the field of Automated Driving, Connected Vehicles and new business models.

E-mail: christian.burkard@fka.de

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fka Forschungsgesellschaft Kraftfahrwesen mbH, Aachen

As a partner in the automotive industry, fka Forschungsgesellschaft Kraftfahrwesen mbH, Aachen offers innovative solutions and engineering services. Understanding the vehicle as a complete physical, energetical and informational system, fka develops solutions relating to the key themes of energy efficiency, safety and driving pleasure - driving innovations.

Corresponding to its main areas of work, fka comprises ten departments: body, vehicle concepts, chassis, drivetrain, acoustics, electric/electronics, driver assistance systems, thermal management, driver experience as well as strategy & consulting. This wide range of competencies enables analysing and optimising the vehicle as a whole paying attention to the complex interactions between its individual subsystems. Powerful computer resources, latest commercial simulation software, various workshops and numerous testing facilities support fka’s activities.

The spectrum of services offered by fka Forschungsgesellschaft Kraftfahrwesen mbH, Aachen in cooperation with RWTH Aachen University's Institute for Automotive Engineering (ika) covers the concept development, simulation and design of vehicles, systems and components, right through to prototype construction and testing. fka carries out specialised and interdisciplinary development tasks, supplemented by technical and strategic consulting.

www.fka.de

Strategy Engineers GmbH & Co. KG

Tel.: +49 89 4161 7235
Fax: +49 89 4161 7237
www.strategyengineers.com
info@strategyengineers.com

Munich

Seidlstraße 18
80335 Munich
Germany

Shanghai

Room 2001, Henderson Metropolitan, No.300 East Nanjing RD

200001 Shanghai
China

HRA 96163, Munich District Court
represented by: Strategy Engineers Verwaltungs GmbH,
Managing Director: Dr. Albert Neumann