KPMG

Co-financed by the Connecting Europe Facility of the European Union

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Automotive Data Sharing

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Executive summary

Data sharing in the automotive industry
The usage of data in the global automotive industry has been increasingly important the last couple of years. Even though Original Equipment Manufacturers (OEMs) have been collecting data from their connected vehicles for several years, they have just recently started to investigate opportunities for sharing the data. OEMs have traditionally been reluctant to this, because of the uncertain value potential of their data. However, during 2019 and 2020, the OEMs have gradually been accelerating sharing of vehicle generated data with third parties and penning deals with both data aggregators and data marketplaces. These deals are creating new revenue streams for the OEMs.

Safety Related Traffic Information
Throughout our interviews, utilizing Safety Related Traffic Information (SRTI) have been a persistent topic. SRTI is regulated under the ITS Delegated Act 2010/40/EU, delegated regulation (EU) No 886/2013. A notable consortium trying to promote data sharing of safety related traffic information is the Data Task Force. Through the pilot projects they are sharing SRTI, and governments are running projects to realize the EU target of 50% reduction in road deaths and serious injuries in the period 2021-2030, and reach 'Vision Zero' – zero road deaths – by 2050.

The ecosystem
The global automotive ecosystem is complex and partnerships are fluctuating. A company that have been mentioned by several of our interviewees is Here Technologies, owned by – among others - Audi, BMW, Daimler, Mitsubishi, Bosch and Continental. Some of these brands are also participating in the Data Task Force, as well as sharing data through data marketplaces such as Otonomo. Other service providers, like TomTom, is actively working on promoting sharing of vehicle generated location based data, and are providing SRTI and Real-Time Traffic Information (RTTI) through the National Access Points set up by EU Member States.

Data initiatives from National Road Authorities
National Road Authorities (NRAs) are looking to utilize vehicle generated data. They are, under the ITS Delegated Act 2010/40/EU, required to share data through National Access Points. Some have chosen to comply only with the regulations, while others have taken a more proactive approach to improve road operations and traffic safety in their country. Later this year (2020), the EU Member States will provide a new update on their progress with the National Access Points. We have seen a number of data initiatives from the NRAs, and some are even starting to pilot Vehicle to Infrastructure (V2I) use cases. Some notable mentions of V2I applications are:

- Ingolstadt in Germany – also known as Audi City – are working with TTS and Audi to enable traffic lights to communicate with Audi vehicles.
- Barcelona in Spain are collaborating with SEAT, DGT, Barcelona City Council and ETRA on connecting vehicles with traffic lights and information panels via the DGT 3.0 platform

Monetizing data
As the number of connected cars on European roads continues to rise, enormous amounts of data are being generated. This data is valuable for a number of different actors, and the OEMs are to an increasingly degree investigating ways to monetize the data while keeping in control of the data and handling data privacy concerns. There have been discussions on the market dynamics on an EU level, but due to the conflict between stakeholder interests they have not yet found a solution that is acceptable for all parties involved.

Data Privacy
Data privacy is seen as a high priority by the OEMs as leaks or issues will have a negative effect on the trust, reliability and reputation of the brand. This is the main reason why OEMs are still hesitant about utilizing and sharing data.

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Project background

The transport and mobility industry are undergoing rapid changes as technological solutions, customer expectations and needs, social and environmental concerns are continuously developing and increasing. Will masses move from public transport to personal mobility, from owning to subscribing, or will hybrid models be the future of mobility? The automotive industry is embracing connectivity to a varying degree to meet the shift in market requirements. There is unique opportunities to rise ahead for those working on new ways to combine these elements, not only technologically, but also profitability.

On behalf of Statens Vegvesen, the Norwegian Public Road Administration, KPMG has conducted a research on data sharing in the automotive industry. The report is ordered in context of the NordicWay 2 project. National road authorities (NRAs) believe in the benefits of automation, and the vehicle manufacturers are bringing more and more advanced products to the market. The development of connected and autonomous vehicles requires information to be shared between road authorities and vehicles, V2I-communication.

In the near future, European connected cars could become a part of the Cooperative Intelligent Transport Systems (C-ITS), which will allow road users and traffic managers to share information for a safer and more efficient transport system. NordicWay 2 and NordicWay 3 are C-ITS pilot projects that enable vehicles, infrastructure and network operators to communicate safety hazards and other information from roads in the Nordic countries between different stakeholders.

In the NordicWay 2 project, Norway has a pilot to investigate readiness for automation. However, they need to obtain a broader understanding of how NRAs can accelerate automation in the road-based transport sector. Hence, a pilot exploring communication, positioning and human/machine readability has been conducted through the Nordics in a 5000 kilometers long data collection expedition. The preliminary results from the expedition show that there are some issues with all aspects; communication, positioning and infrastructure readability.

For automation to continue at a rapid pace there is a need for increased dialogue between vehicle manufacturers (OEMs) and NRAs. To investigate the readiness for automation through increased adoption of connected vehicles, we have conducted a research, interviewing stakeholders in the automotive industry.

Stakeholders from both automotive car manufacturers, authorities with services related to road operations, technology providers and a few other relevant stakeholders have been interviewed. The interviews have aimed to cover four groups of questions:

1. What data is useful for OEMs?
2. What data is useful for road operators?
3. Which technological solutions for data sharing of vehicle data exists?
4. How to share incurred costs for data sharing?

The problem to be investigated and outlined in this report is thus the connectivity in the automotive industry; what data are useful for the different players in the industry, and what technological solutions are utilized to enable data sharing between road users and road authorities?

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NordicWay is a pan-Nordic collaboration on C-ITS related services

NordicWay 1 was an EU project to test and demonstrate the interoperability of cellular cooperative ITS (C-ITS) services both for passenger and freight traffic, piloting continuous services offering a similar user experience in the whole NordicWay network in Denmark, Finland, Norway and Sweden. NordicWay was a real-life deployment pilot, aiming to facilitate a wider deployment in the Nordic countries. The project followed the policy guidance of the European Commission, and was supported via the Connecting Europe Facility (CEF) programme managed by INEA.

The NordicWay 1 project was followed by NordicWay 2 and 3, that had a broader scope in terms of technology and cities included. These are said to enable vehicle, infrastructure and network operators to communicate safety hazards and other information from roads in the Nordic countries between different stakeholders.

Nordic WAY

All projects are built in the “Nordic Way Interchange” node that connects all operators and vehicles together, and uses cellular network for communication with the end user. More than 1800 vehicles have contributed in sharing data. The current NordicWay 3 project consist of several demonstration sites where different elements of connected driving is being tested. Examples are “Automated driving in arctic conditions” in northern Sweden, “Norwegian C-ITS services for challenges in high volume highways” and “Hazardous location warnings and real-time information from the National Danish Traffic Center”.

In summary, the Nordic Ways projects aim to demonstrate the use and feasibility of C-ITS services in the challenging Nordic environment. The projects have shown that cross-border cooperation is possible, and the NordicWay 3 project will continue to roll with a total budget of 19.0 M EUR.

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Chapter 1:

The Automotive Ecosystem

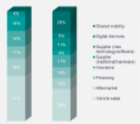
Chapter 1: The Automotive Ecosystem

The automotive data ecosystem is large and complex, with fluctuating partnerships and alliances. Many players are working on positioning themselves in a future-ready place in the ecosystem. In this chapter we will therefore dive into topics related to the automotive data ecosystem, vehicle communication, use cases for vehicle generated data and market dynamics.

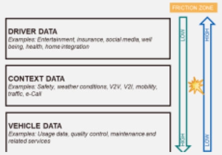
1. The automotive ecosystem
The automotive ecosystem consists of a complex set of services where integration and management of a large number of actors, functionality and services with interdependencies

2. Vehicle communication definitions
A car can be connected to a number of other entities for different purposes and use cases.

3. Commercial and socio-economic use cases for vehicle generated data
Connected vehicles enables a vast amount of use cases in the automotive ecosystem, which is the driver of the potential value.



4. Value of vehicle generated data
The value of the data heavily depends on the use case, and therefore the same dataset can be priced differently depending on the customer and the use case.



5. Market dynamics
The friction zone in the car data market is determined by the strategic importance of the data for car manufacturers, and the penetration by digital platforms.

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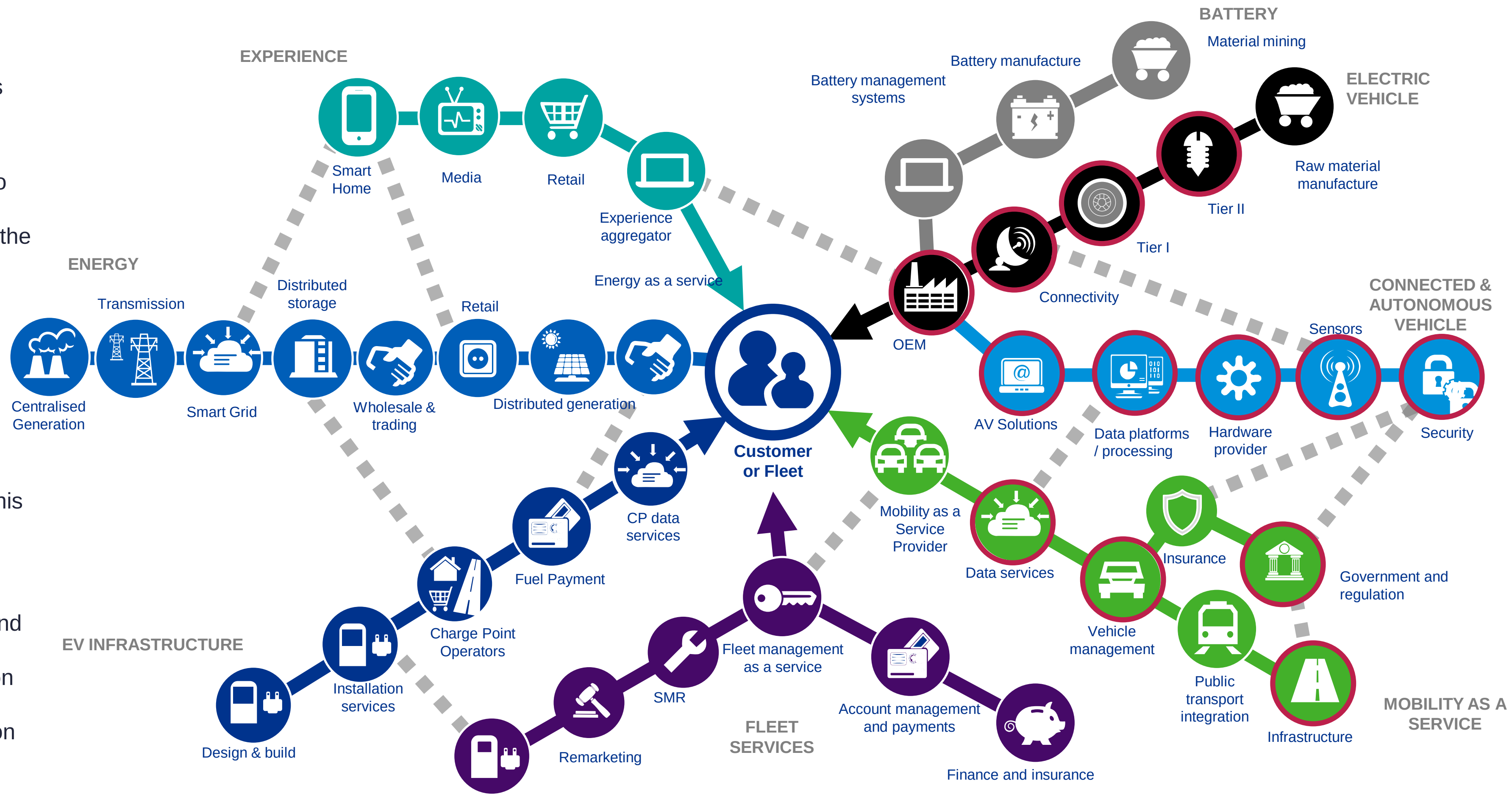
The automotive ecosystem becomes increasingly complex when exploring data sharing between the actors

The automotive ecosystem consists of a large number of players with a complex set of interdependent actors, services and functionality.

In this figure we have chosen to present the ecosystem from a customer perspective showing the full picture of services and categories involved. The functionality most relevant for digitalisation of communication between vehicles and transportation infrastructure are found in the rightmost area of the figure. Functions directly affected by this digital journey have been highlighted with red circles.

The development of services and functionality will require an effective but balanced regulation from authorities, functional standardization and coordination between manufacturers, authorities and other actors.



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Vehicles can communicate with a vast amount of different entities

A car can be connected to a vast amount of other entities for different purposes. Today, the main focus is on connectivity to increase road safety and increase automation, however, other usage is also explored by different actors. Examples on other usage is optimizing traffic flow, reduce traffic congestion, which in turn will also reduce the environmental impact of transportation.

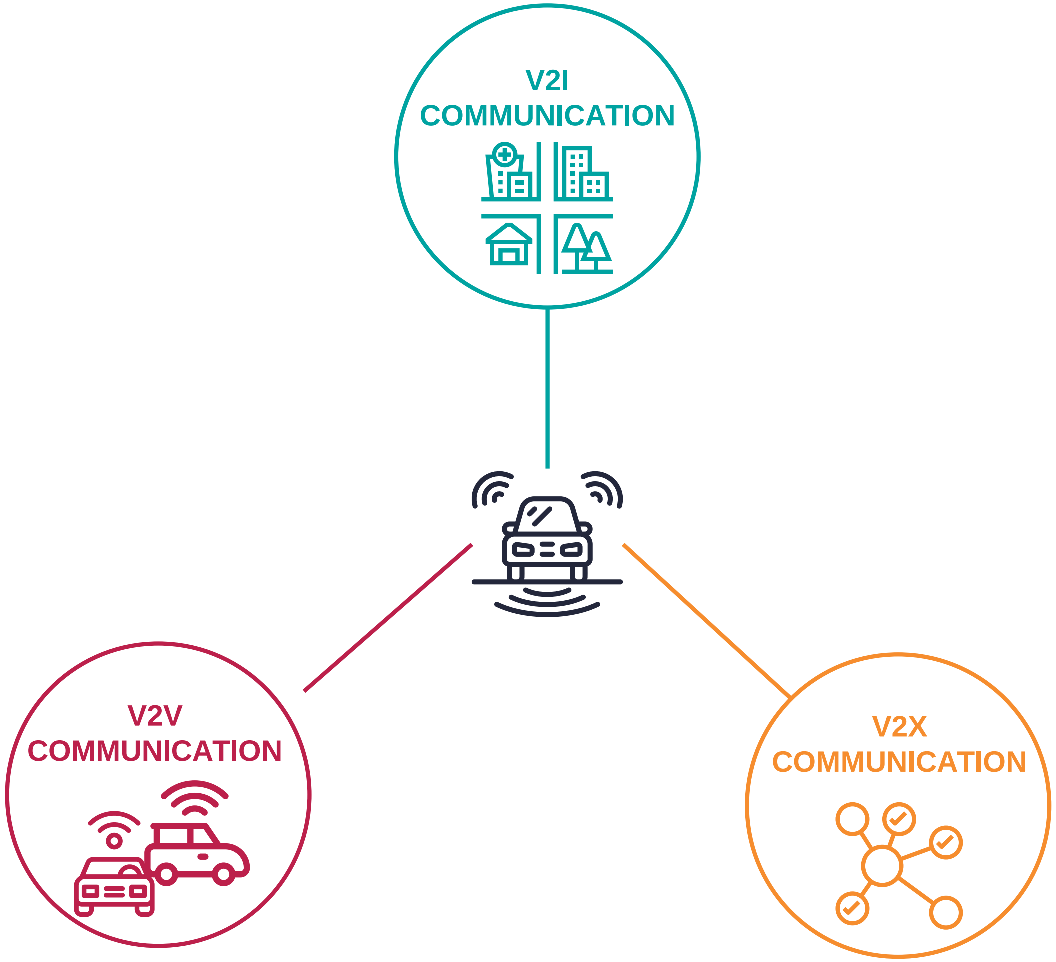
For the purpose of this report we will divide the ways a car can be connected into three categories:

- **Vehicle to infrastructure (V2I):** allows vehicles to share information with components that support the infrastructure. It is anticipated that over time the majority of authorities will collect data from connected vehicles in some degree. In addition to increasing road safety, available live data from vehicles enables intelligent traffic management systems (ITS), which for example can be used to dynamic speed limits and route optimization for vehicles with respect to time and congestion levels. For now, the most used V2I communication is between onboard units and roadside units through DSRC (which we will explore later in the report).

- **Vehicle to vehicle (V2V):** enables vehicles to exchange information between each other. Examples on information that can be exchanged are speed, location, accidents, hazards, road conditions and heavy rain. V2V communication can increase safety through improved performance of vehicle safety systems.

- **Vehicle to everything (V2X):** this term will in this report include all other ways a car can be connected, including cloud, pedestrians, bicycles, e-scooters, homes and so on. Communication with the surroundings through V2X communication is also increasing safety and efficiency by making the invisible visible.

Concerns are raised regarding the ownership of the data. Collection and use is in many cultures seen as an intervention into citizens data privacy.



Vehicle generated data has a broad set of use cases with great potential value

Connected vehicles enables a vast amount of use cases in the automotive ecosystem. In general, the commercial use cases are driven by two purposes, generate income or reduce costs. Players in related industries, complementary industries or even non-transport related industry might be interested in utilizing connected cars and vehicle data to enable use cases for one or both of the two purposes. The following table is not exhaustive, but gives insight into some of the most common use cases for vehicle data, to generate income and reduce costs respectively.

Generate Income

Mobility as a Service

- Car pooling, P2P car sharing
- On-demand mobility services
- Subscription services

Insurance

- Proactive notifications
- Pay as/how you drive
- Crash detection and alarms

Drive Insight

- Targeted advertisements, products and promotions
- Route prediction and optimization
- Vehicle usage monitoring and scoring

Reduce Cost

Demand-driven Service

- Predictive maintenance
- Early recall detection and software updates over the air
- Vehicle condition monitoring service

Automotive

- Fleet management
- Engineering lifecycle management
- Data-/feedback based R&D optimization

Energy & Eco

- Driving style suggestions
- Incentives and optimization
- Recharging monitoring and planning

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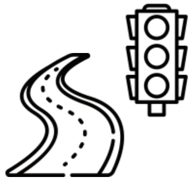
Vehicle data use cases also has socio-economic benefits related to safety, quality and sustainability

DYNAMIC ALERTS



Data has a great potential to improve the road safety. This is for example seen through the NordicWay project, where Scania and Volvo provide road hazard warnings through cloud data exchanges. Drivers receive relevant information and warnings based on location and use this to improve driving behavior.

Automatic emergency calls are also presented as an example. With more rapid assistance, other road users are less likely to get involved which also results in improved safety.

ROAD QUALITY

By using car generated data, maintenance can be done more targeted when needed rather than routinely. This will increase efficiencies for the road operators as well as a generally higher road quality, due to the fact that corrections will be done when needed rather than at the next planned maintenance.

As a result the driver will have a better driving experience, and the cars driving on the roads will suffer less damage from poor quality roads.

SUSTAINABILITY

Emissions may be reduced as a result of usage of car generated data. Factors causing emissions to decrease are:

- Smart routing. Less time in traffic, and more efficient routes.
- Dynamic speed limits
- Distribution on the infrastructure to avoid congestion
- Access to live data so users can travel at less busy times

ACCIDENT RATE

By using car-generated data, the accident rate has potential to decrease. More data will be collected for exposed areas so that safety measures can be implemented at those locations.

By collecting a wide range of data, municipalities can determine whether for example a speed reduction, a change in infrastructure or increased use of road signs is the best action to reduce the accident rate.

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The value of vehicle generated data is estimated to be USD 450 to 750 billions by 2030

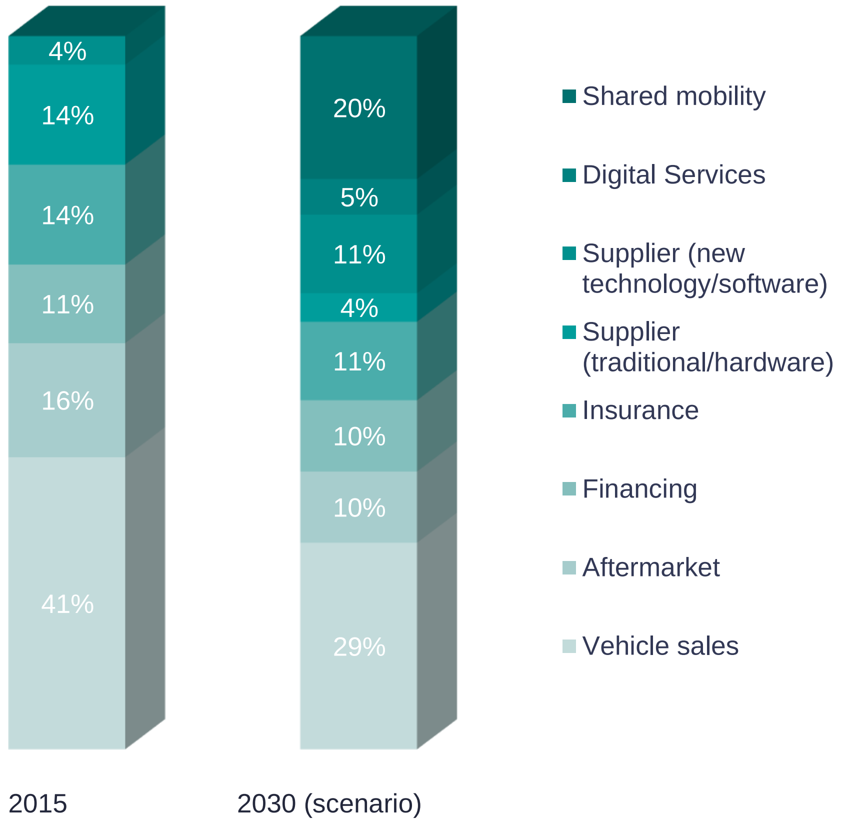
The global value of vehicle generated data will grow in the coming years. However, there are many uncertainties when trying to estimate the future value of the vehicle generated data. This is mainly due to the fact that the value of the data heavily depends on the use case, and therefore the same dataset can be priced differently depending on the customer and the use case. In addition, a data aggregator can create addition value by compiling and contextualizing data, and further sell this at a higher price giving the data exponential value. Furthermore, car manufacturers, tier 1s, data aggregators and other interested parties are restrictive in their sharing as well as indicating their valuation of this data. As the interest in vehicle generated data is increasing, the value of the data itself is increasing too. This all adds up to a complicated and complex picture when trying to estimate the total value of vehicle generated date.

Yet, there are some concrete estimates of the global value that are widely accepted as an estimate. The estimated value referred to by the majority of publications the last few years is set to USD 450 – 750 billions by 2030[1]. This indicates a massive growth in the coming years.

A shift in the auto industry profits is expected in the near future. The weight will be shifted from vehicle sales over to digital services and shared mobility. This substantiates the indication of increased value of vehicle generated data in the future[2].

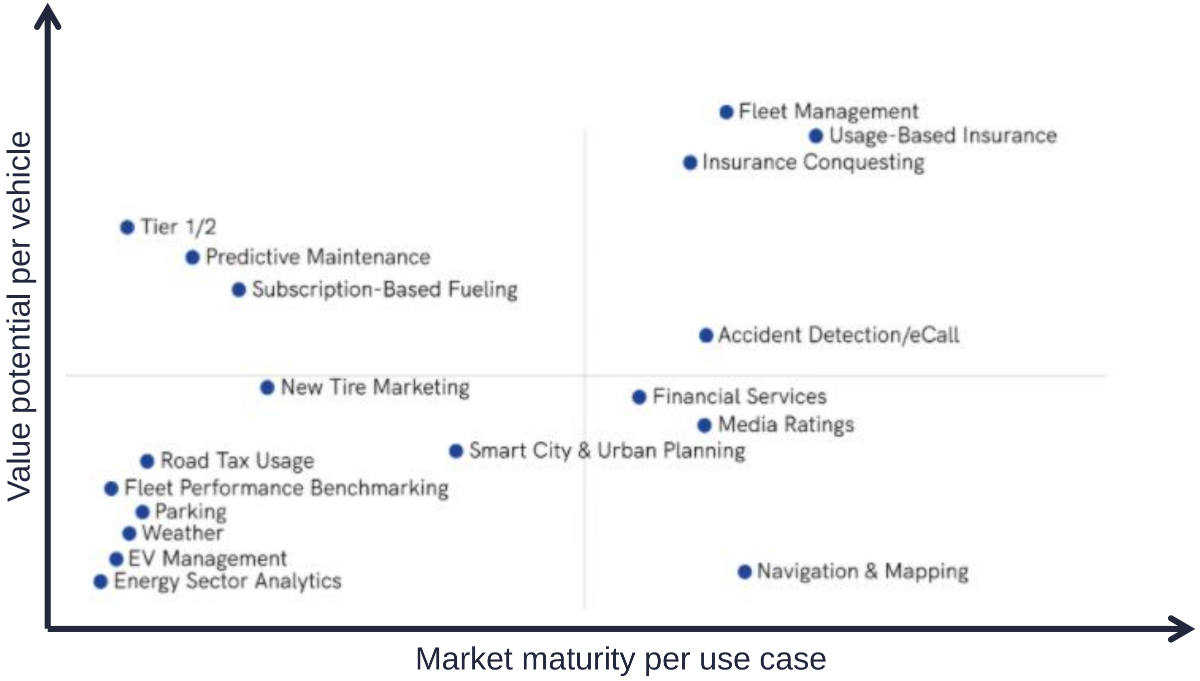
Today, hardware is still the typical manufacturing company's "bread and butter," accounting for more than 60 percent of the value with software and services making up the rest. As digital proliferates, the balance is shifting. The price of hardware is increasingly coming under pressure as machine prices continue to drop, and software and services are expected to make up the majority of value in the near future. Looking ahead, the value-add is increasing in digitally enabled services, software, and machine integration[3].

Scenario for a value shift in the auto industry profits, 2015-30



Market maturity and value potential per vehicle are driving factors for determining the industry adoption of use cases

The data aggregator Otonomo have created what they call the OtoGraph, where they present the maturity of markets in terms of data utilization. This is done by evaluating the market maturity per use case and the value potential per vehicle. The market maturity per use case is evaluated based on how mature the relevant industry players are on utilizing data to enable new services. The value potential per use case is evaluated regardless of their maturity degree, and differences are mainly driven by the type of data use cases utilize, especially related to the degree of personalization versus aggregation of data offering more general services. However, the more personalized use cases requires consent from customer and will thus be more complex to succeed with, and more costly[5].



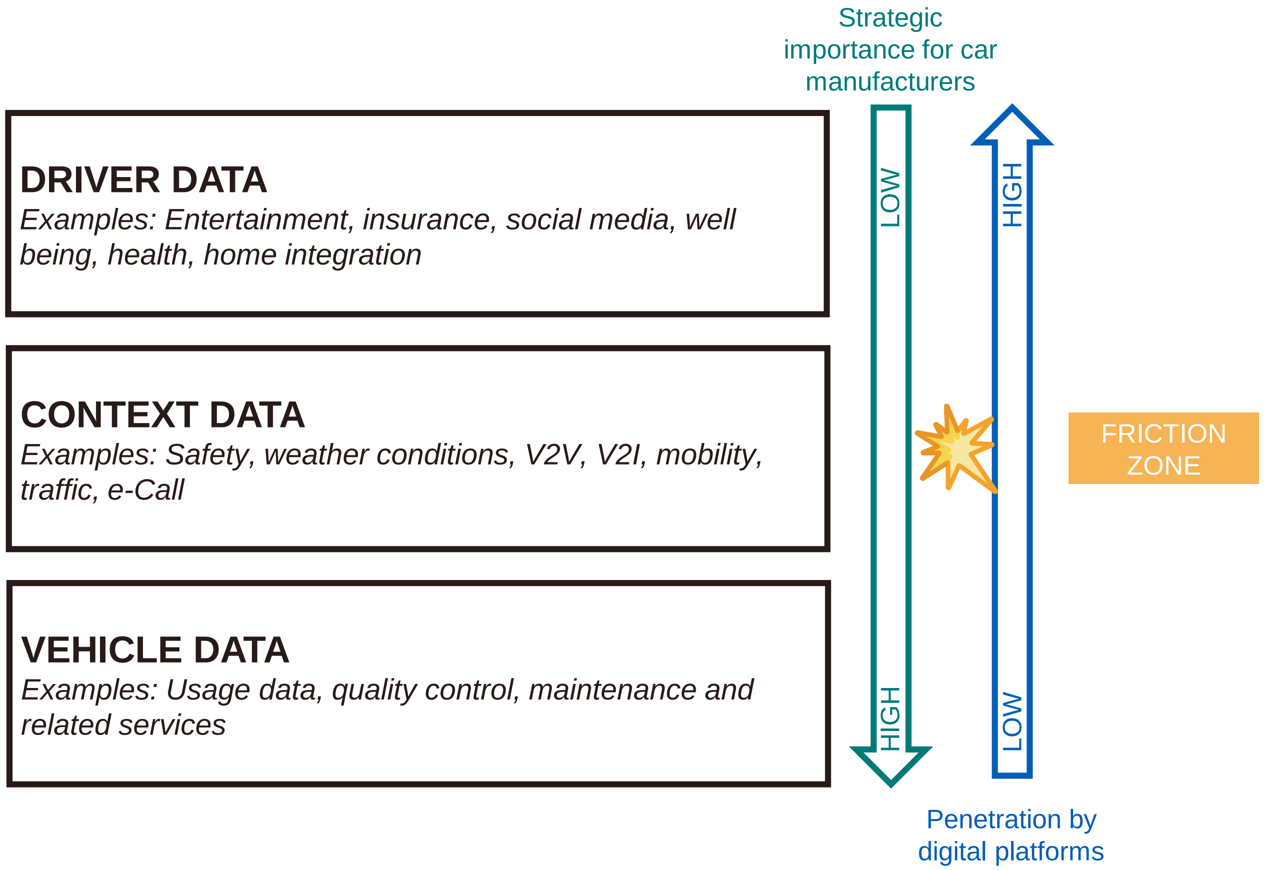
Key takeaways

The market is most mature for the Usage-Based Insurance (UBI) use case, and this underlines how mature the market actually is for vehicle generated data. The market for UBI is USD 24 billion in 2019, and is expected to grow to USD 126 billion by 2027 – mostly driven through increased adoption of connected cars.[4]

Use cases like Electric Vehicle Management, Road Tax Usage and Subscription-Based Fueling with lower market maturity are still in their early phases when utilizing data[5].

At an ecosystem level, we see a surge in connected vehicles on the roads, which leads to more and more vehicle generated data streaming through data platforms every day. As a result, Otonomo expect that all highlighted use cases will move to the right in the graph as the market maturity increases and the market becomes more mature in terms of utilizing vehicle generated data to provide driver services[5].

The dynamics in the car data market has varying levels of friction related to different data types



MARKET DYNAMICS

Vehicle data have a potential to generate exponential value, as it is possible to re-sell the same data to different actors to solve different use cases. With more parties interested in capturing the value from vehicle generated data, the market is becoming increasingly competitive.

The friction zone in the car data market is determined by the strategic importance of the data for car manufacturers, and the penetration by digital platforms[6]. Driver data has high penetration by digital platforms, while vehicle data has low penetration. Strategic importance for car data on the other hand is high for vehicle data, while it is low for driver data. However, context data has medium penetration by digital platforms, and medium strategic importance for car manufacturers. This is where the friction will be the strongest.

The strong friction related to context data can imply increased complexity and competition for national road authorities (NRAs) like Statens Vegvesen in accessing and gathering data. The context data is relevant for the OEMs to improve their products and services, to both increase customer experience and operational excellence. Digital platforms are interested in aggregating this data on their services to provide to consumers of data. The contextual data adds value to both vehicle data and driver data.

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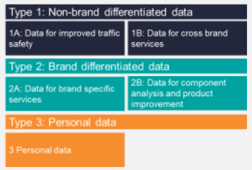
Chapter 2:

Data in the Automotive Industry

Chapter 2: Data in the Automotive Industry

Even though the exact value of car data is difficult to estimate, consensus is that car data has great potential value for a number of related products and services. Car data consists of a large amount of data points from different sources. When elaborating on the use of vehicle generated data and connected vehicles in this report it is important to understand the building blocks of vehicle data. In this chapter we will therefore outline a few important topics related to automotive data sharing and vehicle generated data.

1. Building blocks of automotive data
Which static and dynamic layers does automotive data consists of, and what data sources makes up the different layers. This is important for obtaining an understanding of how important frequency in data loads are for different types of data.



2. Types of vehicle generated data
When we present the data types of vehicle we will separate these into 3 groups and 5 sub-groups. Understanding the groups are important to get an overview over the possibilities to use different types of vehicle generated data, as the different groups have different degree of privacy issues and brand specific information.


DSRC

CELLULAR

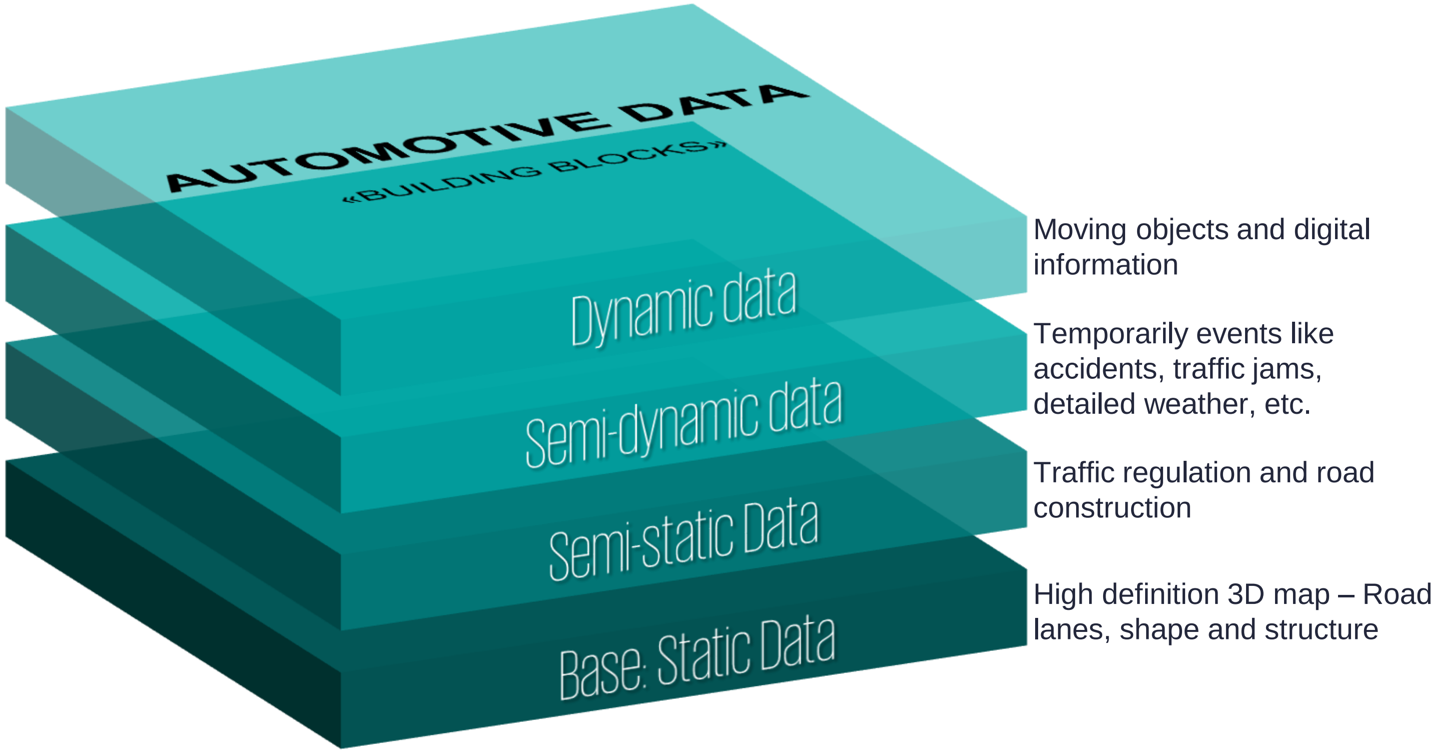
3. Types of V2V / V2I / V2X communication
Understanding the different possibilities for vehicle communication is important to understand the enablers for data sharing. Different solutions have different strengths and weaknesses in terms of latency, connectivity, uptime and so on.

4. Data privacy
The consideration of data privacy will always be important in relation to data sharing independent of industry and use cases. In the automotive industry, data privacy and security is a top prioritized focus area. Understanding data privacy is important to come to terms with the limitations of data sharing.

Building blocks of automotive data

There are different views on what data is needed in order to reach higher levels of automation in the road based transport/mobility sector. An ongoing Field Operational Test (FOT) project in Japan – Tokyo Waterfront Area - is exploring how to utilize data to increase automation in situations that could be difficult to handle for autonomous cars solely based on their sensors and other devices installed in the vehicles. The project is using information from the traffic infrastructure on the road side to reach higher levels of automation. Next, we will outline the building blocks of automotive data as described by the FOT project.

The building blocks of automotive data consists of four connected layers of data, from static to dynamic data



DATA LAYERS

Automotive data consists of data layers with different degrees of dynamic properties[7]. Focusing on vehicle generated data and infrastructure data (C-ITS data), the data can roughly be divided into the following four groups:

- **Static data:** makes up the base for automotive data, consisting of map data, including road lanes, shapes and structures. An enabler for autonomous driving are high definition 3D map, but this will also be beneficial for connected and assisted driving.
- **Semi-static data:** are adding the layer of temporarily events with long perspective, examples are traffic regulation, road construction, and seasonal weather conditions.
- **Semi-dynamic:** consists of information about temporarily events with short time line. This can for example be detailed weather, accidents, and traffic jams.
- **Dynamic data:** are the top layer which includes moving objects and digital information. Examples on this are movements of vehicles, status of pedestrians, traffic signals

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Types of vehicle generated data

Modern vehicles already have up to one hundred on board control units that constantly communicate with each other to ensure correct driving and customer functionality. In order to understand what data that is available, we will in the following page show a categorization of the different data types. This categorization is widely used in different forums. Our categorization is a combination of the Verband der Automobilindustrie (VDA) categorization in their position paper for access to the vehicle and vehicle generated data (2016), and the categorization in SMMT Connected and Autonomous Vehicles position paper (2017).

Vehicle data can be separated into three types, and five sub-categories

	Type 1: Non-brand differentiated data		Type 2: Brand differentiated data		Type 3: Personal data
	1A: Data for improved traffic safety	1B: Data for cross brand services	2A: Data for brand specific services	2B: Data for component analysis and product improvement	3 Personal data
What	• Data providing social benefits in terms of improved traffic management and safety	• Defined datasets cross OEMs consisting of non-differentiating anonymized vehicle data for potential third-party commercial services	• Differentiating OEM specific dataset consisting of OEM specific anonymized data and data with IP relevance	• Differentiating vehicle data and IP relevant for OEM an supplier, component specific anonymized dataset	• Data that supports services that require identification of the user or the vehicle, including but not limited to the VIN
Use Cases	• Local hazard warnings, activation of hazard lights, accident position, position of active emergency vehicle, road blocks, icy roads, potholes, average speed/traffic flow, ambient temperature	• Ambient temperature, average speed/traffic flow, road sign recognition, on-street parking	• Lane marking perception, chassis sensor data determining road condition, engine operating map, gearbox operating map, proprietary sensor data, software algorithms	• Actuator data, engine injection behavior, fuel pump performance, automatic transmission shifting behavior, fault memory data, battery performance, stability, control data, battery status, break pad wear	• Vehicle location, movement profile, average speed, fuel and consumption levels, navigation destinations, address book, infotainment settings, acceleration, personalized services and in-car settings, health and wellbeing data
Stakeholders	• Public and local authorities, and road users	• Commercial and non-commercial third-parties, e.g. app developers and aftermarket	• Vehicle manufacturer, partner(s) on vehicle manufacturer's behalf (dealers, subsidiaries)	• Vehicle manufacturer, supplier(s), partner(s) on vehicle manufacturer's behalf	• Only parties authorized to process data by law, contract and consent (e.g. insurers, app developers)
Enablers	• Anonymized data - that will require only individual agreement with vehicle manufacturer	• Anonymized data - that will require individual agreement with customers and third-party market participants	• IP relevance OEMs, but anonymized data - that will require individual agreement with customers and third-party market participants	• IP relevance OEMs and supplier(s), but anonymized data - that will require individual agreement with customers and third-party market participants	• User identified and personal data protection relevance is sever

Categorization based on SMMT (8) & VDA (9) position papers

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Types of V2V / V2I / V2X communication

In this new age of connectivity, there are a number of ways cars can communicate between each other and with the road infrastructure. We will present the two, in our opinion, most important communication methods utilized in the road based transport sector. Next, we will explore both DSRC and cellular communication, as well as some real life example of the usage.

There are two main types of communication technologies for connected vehicles

V2V, V2I and V2X-communication makes it possible for vehicles to receive information from their environment before the driver would normally know about it. The enabler for this is communication technologies such as Dedicated Short Range Communication (DSRC) and cellular networks (4G LTE and 5G). Connected vehicles have a great number of potential use cases, but some of these require communication between all vehicle types and infrastructure.

DSRC / ITS G5

A WiFi-based protocol for high-speed wireless communication between vehicles and infrastructure. It has two operating modes: V2V or V2I, and can provide communication in presence of obstructions, fast-changing environment, and in extreme weather conditions.

The main benefits of this communication technology is the maturity and readiness for deployment and adoption, which will allow possible use cases to be deployed near term. It has also proven to be superior in the ability to communicate directly as it is not relying on network, which has advantages in rural areas, and proven low latency, which is important for safety messages and driver warnings.

However, the adoption of DSRC will require an investment related to road side units to support the adoption of V2X-communication solely, and up to now the adoption has not been as broad as earlier expected. In addition, there is not any further development on the roadmap to meet future demands, and it cannot meet the higher bandwidth demands from autonomous vehicles.

Companies like VW and Volvo have been utilizing this technology in their cars.

CELLULAR

Cellular communication technology used for V2X-communication are currently utilizing 4G LTE. The OEMs and Governments arguing for the use of cellular network are, however, relying on the development and roll out of 5G network to ensure an efficient network for V2X-communication.

The benefits of utilizing cellular networks are the continuous development and improvement of the technology, combined with the ability to be backward and forward compatible (2G, 3G, 4G, 5G). Cellular networks are already available throughout the developed world, and it will be deployed regardless of V2X-communication systems, hence, no additional investments are necessary.

Currently, there are some limitations using cellular networks, the main one being the limited-ability bandwidth. The adoption of 5G will, however, eliminate this by enable a dedicated bandwidth for V2X-communication. Latency is another limitation together with the dependency on being connected to the network which is no guarantee in rural areas.

Ford have stated that they will aim for cellular connectivity in their new cars.

There are a few hubs for autonomous driving in Norway, and these are mainly utilizing DSRC for V2I communication. Which enables the vehicles to communicate directly and securely with the surroundings without the use of cellular infrastructure. The properties of DSRC also in extreme weather conditions have enabled testing of AVs also in extreme environments like Svalbard and for snow and ice clearing at Oslo Airport.

In the US the amount of vehicles with embedded in-vehicle cellular systems increased by 22% from 2017 to 2018, reaching 41 million vehicles[10].

The ZalaZone have since 2019 been testing and piloting 5G developments. In this environment Magyar Telekom, T-Systems and Ericsson showcased a joint activity on how to control a fully automated vehicle within a complex traffic scenario over 5G communication, including communication between vehicles and the control center[11].

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Data Privacy

Privacy and data security is at the top of the agenda of automotive companies. Companies must be clear about their intentions for the use of vehicle generated data when obtaining consent from the customer. Data privacy is seen as a high priority by the OEMs as leaks or issues will have a negative effect on the trust, reliability and reputation of the brand. This is the main reason why OEMs are still hesitant about using and sharing data. Data privacy is a large topic, and this report will limit its content to an overview of the subject. It is important to understand the roles, outlined on the next page, when dealing with automotive data.

Identifying the data subject, data controller, data processor and data authority is important to be compliant with data protection regulations

Data Privacy & GDPR

Throughout our interviews, there have been broad consensus in who is the data owner when it comes to vehicle generated data. All interviewees agree that the driver and the owner is the appropriate entity to ask for consent. In situations where the owner is a fleet owner, the fleet owner will be responsible for obtaining consent from the drivers. Both OEMs and data aggregators have their own solutions for consent management, which is essential if you want to use vehicle generated data for use cases that utilize vehicle generated data on a unaggregated level. All data processing in the EU needs to be compliant with GDPR.

Data Subject: the driver or the fleet owner is the data subject, and in such the owner of the data.

Data Controller: the OEM is the one collecting the data, and in such the data controller. Thus, the consent management and security, including data privacy issues should be handled by the OEM.

Data Processor: are the ones utilizing the data. These are the data aggregators, data marketplaces and service providers accessing and using the data.

Data authority: in all European nations there is a data authority which provides different regulations and legislations related to data sharing, in addition to the ones provided by EU.

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Chapter 3:

The OEM Perspective

Chapter 3: The OEM Perspective on Data Sharing in the Automotive Industry

The OEMs have a key role in the development of connected vehicles, and creates the foundation for exploring the opportunities of CAVs and the future of mobility. In general, OEMs are positive about sharing anonymized data, especially for increased traffic safety. In this chapter, we will elaborate on the OEM perspective of data sharing in the automotive industry.

1. Key takeaways from qualitative studies

We will present the key takeaways from the qualitative research we have done by interviewing stakeholders in the automotive industry.

2. Data stream, internal and external data usage

For the OEMs vehicle generated data presents both opportunities for internal improvement and external data sharing. In this part we will present the data stream from vehicle generated data, as well as an overview of the internal and external usage, as well as drivers for data monetization.

- CUSTOMER ATTITUDE
- DATA MANAGEMENT
- DATA QUALITY
- DATA USAGE
- ETHICS

3. Enablers and ethics for data sharing

To realize the potential in vehicle generated data there are some factors that need to be taken into consideration. We will outline some of the most important ones to present the complexity the OEMs face.

4. Partnerships and ecosystem in the automotive industry

In recent years we have seen a trend that OEMs are partnering with players from related industries to deliver greater customer value. We will outline some examples of partnerships and ecosystem for an understanding of the volatile and dynamic market conditions.

5. Road to autonomous driving

Connected vehicles are an enabler for autonomous driving and we will, as a closure of this chapter, present the road to autonomous driving for an understanding of the autonomous readiness in the automotive industry.

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The automotive OEM point of view - key takeaways

Connected Vehicles & Data sharing from the automotive OEM point of view

The automotive OEMs have been on a maturity journey the previous five years in terms of utilizing, sharing and monetizing of vehicle generated data. We have seen an increase in signed partnerships with third party data aggregators and data marketplaces during 2019 and 2020.

There is a broad consensus to share safety related traffic information among OEMs in order to improve road safety, while they have a strong focus on data privacy of their customers – who they see as the data owners. Having their customers trust is essential for the OEMs in order to be allowed to use vehicle generated data to create value-added services to improve customer loyalty.

Some OEMs see data as an asset in creating new business models and revenue streams, while other see data as an integral factor in improving road safety. The first group have multiple ongoing initiatives related to data monetization and utilizing vehicle generated data in improving their cars and providing value-added services to the end users (drivers).

The OEMs are making their data available through their own back-end servers through APIs. End users and third parties may create applications on top of the manufacturers APIs. They are also providing similar data to data aggregators and marketplaces like Here Technologies, Otonomo and TomTom, which creates a “sleeping” revenue stream for the OEMs. Some OEMs prefer that third parties, like NRAs, go through a data aggregator when accessing vehicle generated data.

The OEMs are actively collaborating in multiple groups and consortiums, such as Data Task Force (Data for Road Safety), Nordic Way, Car Connectivity Consortium, Federation Internationale de l’Automobile (FIA) and Alliance for Automotive Innovation to mention a few.

An interesting takeaway from the OEM perspective is that, as things stand now, they will not rely on third party data other than HD maps when pursuing fully autonomous driving due to the unreliability of the third party data.

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OEM data stream, internal and external data usage

The data stream of vehicle generated data is, as discussed, extensive. The data has great value for OEMs to improve both the customer experience and operational efficiency. In addition, OEMs are obligated to share safety related traffic information, and are also positive about doing so, to increase traffic safety. Lastly, OEMs have the opportunity to generate new revenue streams by selling data to third parties, for other service providers to develop services based on vehicle generated data.

Even if OEMs sell data to third parties, OEMs divide the data stream generated from their fleet in an internal and an external data stream for security and privacy considerations.

The vehicle generated data streams have multiple paths based on the usage of the data

Data sources

VEHICLE GENERATED DATA

- User interface
- Control unit
- Sensors

Data gathering

OEM BACKEND SERVER

- Connectivity platform
- Application layer
- Data layer

Handled risks

- Data privacy concerns
- Cyber security risks

Internal data stream

External data stream

Potential revenue stream for OEMs – tangible ROI

Data usage

VALUE ADDING SERVICES

- Personalized services
- Assisted driving

OEM INTERNAL IMPROVEMENT

- Improved processes
- Increased performance
- Improved products

SAFETY RELATED DATA

- Obligated to share
- Available through national access points

SELL DATA TO THIRD PARTIES

- Data aggregators
- Data marketplaces
- Service providers

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Vehicle generated data can be shared by the OEMs for socio economic or commercial purposes

Sharing and use of safety related traffic information is widely accepted as an important factor to increase traffic safety, and OEMs are both obligated to and positive about sharing these data. All use cases which are not safety-related, although they might be in the public interest, are considered to be commercial use cases. OEMs that have CSR high on their agenda are positive to share data for social, environmental and economic benefits, so called triple wins. Further, OEMs use data internally for the improvement of products, services and efficiency. Distribution of data to third parties, either authorities or other actors are more complex. And as one move from socio economic use cases and over to use cases with increased commercial value, the acquiring data becomes more costly and complex.

SOCIO ECONOMIC

LOW — COMMERCIAL VALUE — HIGH

NON-COMMERCIAL

Safety Related Traffic Information

- Delegated act (EU) No 886/2013 for STRI imposes sharing of data related to eight types of events.
- This data is shared with authorities and other service providers through national access points.
- A common understanding in the automotive ecosystem is that safety related vehicle generated data should be shared without compensation.

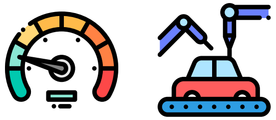
TRIPLE WIN

Social, Environmental & Economic

- Collaborating on research projects and initiatives with social, environmental and economic benefits might be referred to as a "triple win"
- The large amounts of data generated from connected vehicles can be utilized to improve productivity by increasing vehicle and machine uptime, reducing emissions and noise, and improve traffic and site safety beyond the SRTI regulation.

OEM INTERNAL USE

Value adding services & OEM internal improvement



The data generated from connected vehicles can be utilized by OEMs to generate intangible return on investment (ROI) through:

- **Value adding services** includes improved products and services
- **OEM internal improvement** by increased efficiency through processes and data utilization.

The commercial value will for the OEM either be related to increased customer experience and sales or reduces costs due to higher efficiency.

DATA MONETIZATION

Sell data

OEMs can generate tangible ROI by selling data to third parties.

- Data can be sold to data aggregators or data marketplace, who distribute the data further
- Data can also be sold directly to service providers who offer new products and services utilizing the connected car data, for example pay-as-you-drive insurance.

Road operators are obligated to collect and share safety related traffic information, and the OEMs are willing to provide data for this purpose

Vehicle-generated data has a huge potential to help achieve public-interest purposes, such as road safety. The EU delegated act No 886/2013 for safety related traffic information (STRI) regulates what data the road operators shall collect and freely share. The purpose is to improve traffic safety by providing safety related traffic information for free through national access points across Europe. OEMs communicate a positive attitude towards sharing safety related traffic information and data to improve traffic safety, and it is a common understanding that this will not be compensated.

According to the regulation, public and/or private road operators and/or service providers are obligated to share information within the following eight event categories:

Temporary slippery road | **Animal, people, obstacle, debris** | **Unprotected accident area** | **Short-term road works** | **Reduced visibility** | **Wrong-way driver** | **Unmanaged blockage of road** | **Exceptional weather conditions**

Data from automotive OEMs are anonymized and available through their back-end servers. However, it is time consuming and costly to integrate to all OEMs. Data aggregators have tried to solve this problem by harmonizing data across brands. They filter out incorrect and duplicated data, analyze and re-interpret or transform the data in order to obtain usable output. OEMs can share data in two levels, vehicle data (level 2), or road and location data (level 3). Raw sensor data (level 1) is not included in the delegated act.

National road authorities collect the data and make it available through national access points that function as data platforms or databases with links to the data. This is discussed further in Chapter 4: the authorities point of view.

The data from national access points can be utilized either by national road authorities or by other service providers to increase traffic safety. Public data and other private sector data, can be added to the vehicle generated data to contextualize and enrich the information. The data is provided on a Datex II format.

A working group, the Data Task Force, have worked on a Proof of Concept to validate and test the general principles of automotive data sharing in the European Union[12].

"We're more than happy to share this data with other OEMs and service providers. And we have identified lately that the Data Task Force is really the environment where we could make this happen".

– Head of Software Business and Strategy, Automotive OEM

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The Data Task Force is the biggest collaboration in Europe for automotive data sharing, focusing on safety related data

PARTNERS

As a response to the delegated act (EU) No 886/2013 for STRI a European working group was formed in 2017, the Data Task Force. Its goal is to improve road safety by maximizing the reach of safety related traffic information powered by safety data generated by vehicles and infrastructure. Within the ecosystem, vehicle data is shared along with infrastructure data to generate alerts and warnings for drivers in an architecture that would ultimately allow cross-border exchanges to foster pan-European solutions and interoperability.

Data Task Force is one of the largest public-private partnerships on road safety, and consists of Member States, service providers, as well as car manufacturers. Together they are structured around three core principles:

- Working together to make driving safer
- Safety without compromise
- A fair and trusted partnership

The working group have been exploring the business and technical specifications for sharing safety related traffic information. OEMs are prepared to make the safety related traffic information available in an anonymized manner to public authorities, or private operators entrusted with a public task such as road operators. The basis of the ecosystem are built on a decentralized approach on the following four principles:

- Free of charge
- On the basis of reciprocity
- For road safety purposes
- For public authorities

The Data Task Force has since 2017 been working on a Proof of Concept on data sharing for safety related traffic information, and the results was published in October 2020[13]. They show that the data flow gradually has become available, but not with sufficient quality and latency within all categories.

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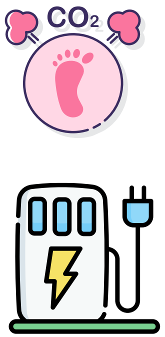
Some examples of data sharing for the benefit of society, environment and economy (Triple Win)



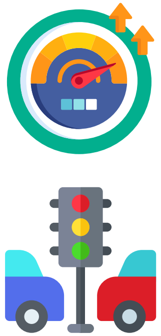
By collaborating with governments, authorities, other public or private companies, OEMs are working on **initiatives to reduce CO2-emissions**. In addition to internal improvements through better insights in the drivers of CO2-emissions, it is a increased focus on **electrification of the main road networks in Europe**. This includes collaboration on charging infrastructure and access to charging stations.

OEMs are working on **improving batteries in electric vehicles**. This includes factors like:

- More sustainable
- More robust with better capacity
- Offered at a more competitive cost
- Recycling and reuse of batteries

This work is not necessarily done only at the OEM site, but also by collaborating with other technology players.

OEMs are working to bridge the gap between academic research, the transport and telecom industry by working with universities, telecom industry and/or other technology providers or start-ups. Together they do research and demonstrations on **new transport infrastructure, vehicle concepts, business models and policies**.



Sharing data to **optimize traffic flow** by enabling V2I-communication will increase efficiency of driving in cities. OEMs have started experimenting with such data sharing in both the US and Europe as a cooperation between OEMs and start-ups. It is enabled by data exchange between vehicles and traffic lights. Data shared is on optimized speed towards green light and time to next green light.

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The internal data stream provides opportunities to capture value for OEMs

VALUE ADDING SERVICES

- Personalized services
- Assisted driving

By utilizing data OEMs are able to provide a vast amount of value adding services to the customer, which will transform and improve the customer experience. OEMs can utilize the data for several purposes:

- **Personalized services** based on the customer's behavior and preferences. This can include services related to the infotainment system, warnings and information about maintenance, and even scheduling of appointment.
- Provide better **assisted driving services** by utilizing aggregated data of all brand-specific vehicles (fleet), for example through better information about road conditions, better hazard information/warnings, better information on traffic incidents.

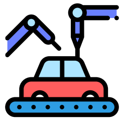
In addition, the internal data stream can be complemented and contextualized by other and external data sources. This will expand the services OEMs can offer to their customers further, for example better street parking assistance, more precise and reliable information on speed limits.

OEMs can also collaborate with service providers to offer more complex services as pre-booked parking, car wash, and car pick-up, service and delivery.

> *"Life time usage, reliability, and improvement are the focus right now. The more commercial use cases are not very successful yet."*

– Senior Executive at an Automotive OEM on how they use vehicle generated data

OEM INTERNAL IMPROVEMENT



- Improved processes
- Increased performance
- Improved products

Through the internal data stream OEMs can achieve extensive internal improvement. This can be driven by:

- More **efficient processes** by utilizing insights to improve internal processes related to for example customer service, research and development, and prediction of demand.
- **Increased performance** through insights into failure rates of vehicle fleet, this includes wear-and-tear of vehicles and maintenance. This also provides opportunity to predict component demand.
- **Improved products** by utilizing insights from current fleet OEMs can improve future products through more targeted research, design, innovation and product development.

Also, by completing and contextualizing the data stream with external sources the insights can be even greater.

> *"Using contextual vehicle data allows us to optimize the maintenance of our fleet by re-calculating the service need out of how the vehicle is used. This also enables us to take seasonal needs into account."*

– Product Owner at an Automotive OEM

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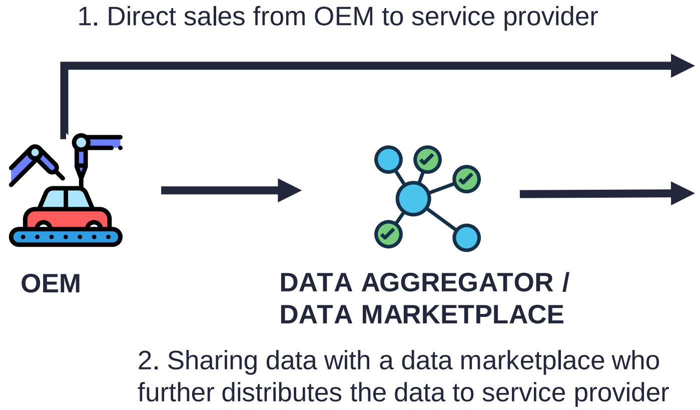
OEM data monetization can be realized either by direct sales, through a data aggregator or a data marketplace



"When providing GPS-related data from the vehicle, we might provide it first to your insurance company for usage-based insurance. We might provide it again to a parking service to help you find parking and perhaps again to a city for smart-city applications. And the data will have a different value each time."

\- Senior Executive at a data aggregator on how to price data

To enable new revenue streams for others

By sharing data with service providers that utilize the data to provide new services, OEMs are enabling new revenue streams for other companies. This can be players in related industries, or in complementary industries, or not related to mobility at all. Some examples are:

- Insurance companies enabling pay as/how you drive
- Marketing companies being able to sell targeted advertisements, products and promotions
- Service providers enabling personalized services, for example through the infotainment system
- Navigation providers being able to provide services as route prediction and optimization
- Service providers offering services to optimize fuel/energy consumption and charging optimization
- Network parking services
- Enables for Mobility as a Service (MaaS): car pooling, P2P car sharing, subscription services

To help others reduce costs

By sharing data with service providers that utilize the data to realize more efficient services or processes, OEMs are enabling reduced costs for other companies. This can be public actors or other private companies in the mobility or vehicle industry. Some examples are:

- Road operators being able to do target maintenance
- Insurance companies to (reduce costs by crash detection, alarms and) overview over driver behavior
- Predictive maintenance on vehicle and automatic scheduling will reduce administration costs at service centers

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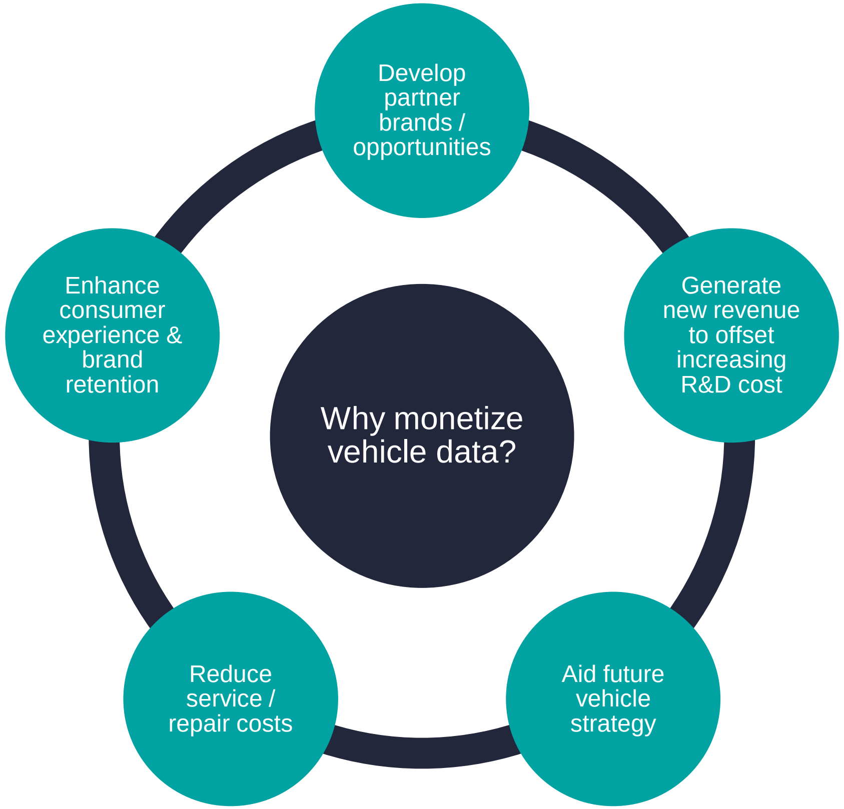
The drivers of data monetization are increased competition, customer experience and change in costs, all affecting profitability of OEMs

To understand how the data economy works in the automotive industry, one has to know why automotive OEMs are trying to monetize vehicle data. It can be divided into five main forces taking into consideration the ecosystem and new, disruptive players, customer expectations, increased R&D and service costs due to more advanced vehicles, as well as the need for agile leadership.

- **Develop partner brands and opportunities**
  Increased desire for autonomous vehicles, shared mobility, fleet management and usage-based insurance opens new, data reliant business opportunities for automakers
- **Generate new revenue to offset increasing R&D cost**
  Increased R&D costs for EVs, autonomous, connected platforms and manufacturing are eating into automaker's profit
- **Aid future vehicle strategy**
  Increasing complexity within the automotive industry is impacting decision makers trying to keep pace with consumer desires
- **Reduce service and repair costs**
  Increased vehicles electronics and component value are negatively impacting manufacturers servicing costs
- **Enhance customer experience and brand retention**
  Increasing competition from industry disruptors means manufacturers must develop higher quality vehicles and services to meet customer expectations and maintain brand retention



14 Information collected from SDB Automotive – *"Data Monetization – Strategies for the Connected Car"* (2019)

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Enablers and ethics of automotive data sharing

As increasingly connected cars evolve to become “computers on wheels”, they will generate more data than ever before, which can benefit consumers by increasing the safety, convenience and enjoyment of journeys.

Maintenance can go from being reactive to predictive, new parts can be ordered automatically and whole fleets can be dynamically managed. In addition, over-the-air software updates can improve vehicle performance without anyone even coming into contact with the vehicle.

From a passenger experience perspective, connectivity should significantly broaden the scope of in-vehicle entertainment, commerce, health and working opportunities. Connected and Autonomous Vehicles (CAV) should also enhance road management, enabling transport authorities to manage capacity on busy routes, using CAV communications infrastructure to keep traffic flowing and reduce congestion.

Enablers for data sharing in the automotive industry are customer attitude, data management, data quality and usage

Customer attitude

As discussed, the customer (driver or fleet owner) is the owner of the data. Hence, unless the customers are willing to share their data, no value will be generated. However, studies show that customers are showing an increasing willingness of sharing their vehicle generated data, and the willingness to share increase as the customer sees the benefits of sharing. Shaping that benefit to something of reasonable value to the customer is important.

Data Management: Integrity, security and privacy

Transparency and consent is important, the driver or fleet owner has to be consistently informed about what data is being collected, how it is used, how it is accessed and stored, and the ability to terminate consent has to be clear to the customer. Compliance with the respective regulations and mandates for data privacy is important, as well as ensuring secure data exchanges, including where data is being sent, originates and whether encryption is used consistently. Lastly, the hardware and software supporting this effort should be forced into the plan of collect, clean, normalize and unify data.

Data quality, frequency and completeness

Simply collecting and aggregating huge amounts of data is unlikely to generate value. To be able to utilize data one should consider the full range of data being captured. This includes what data points should be captured, how frequent, and over what time period. Together with the accuracy, completeness, validity and reliability of the data this makes up the data quality of vehicle generated data. The requirements for the data quality can vary dependent on the use case.

Use of the data

The value is generated when the data is actually used, this could be through a partnership or directly by the OEM. When new opportunities and innovative services are developed, new revenue streams are generated. The more players entering the automotive ecosystem, the higher the profitability will be. Hence, cross-industry cooperation, connecting with complementary partners and services, is a key success factor for generating value on data in the automotive industry.

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The ethics of connected vehicles and data sharing is a continuously evolving topic

Where are we now?

Connected driving is developing fast, but the policy making and risk assessment is lagging behind. By moving too fast, a potential outcome could be that decisions affecting human lives are taken without adequate political debates that ensure safety for all involved parties. In the future, the relation between human beings and connected vehicles is estimated to require more consideration to ethics than any other traffic related area has done before. Concerns around ethics spend from public acceptance to cyber security and data privacy to fast pace of new technology. The list is not exhaustive, and within this field the ethical concerns will become increasingly more complex as new solutions and products are offered.

Public Acceptance

- What role does the government take?
- What and how much data is it acceptable/desirable to share with governments?
- Do regulators have a qualified ground to make decisions on? Must be in a position to make informed choices.
- Public acceptance often based on single failed events, where ethical questions arise.
  - Ex «trolley problem»

Cyber security and data privacy

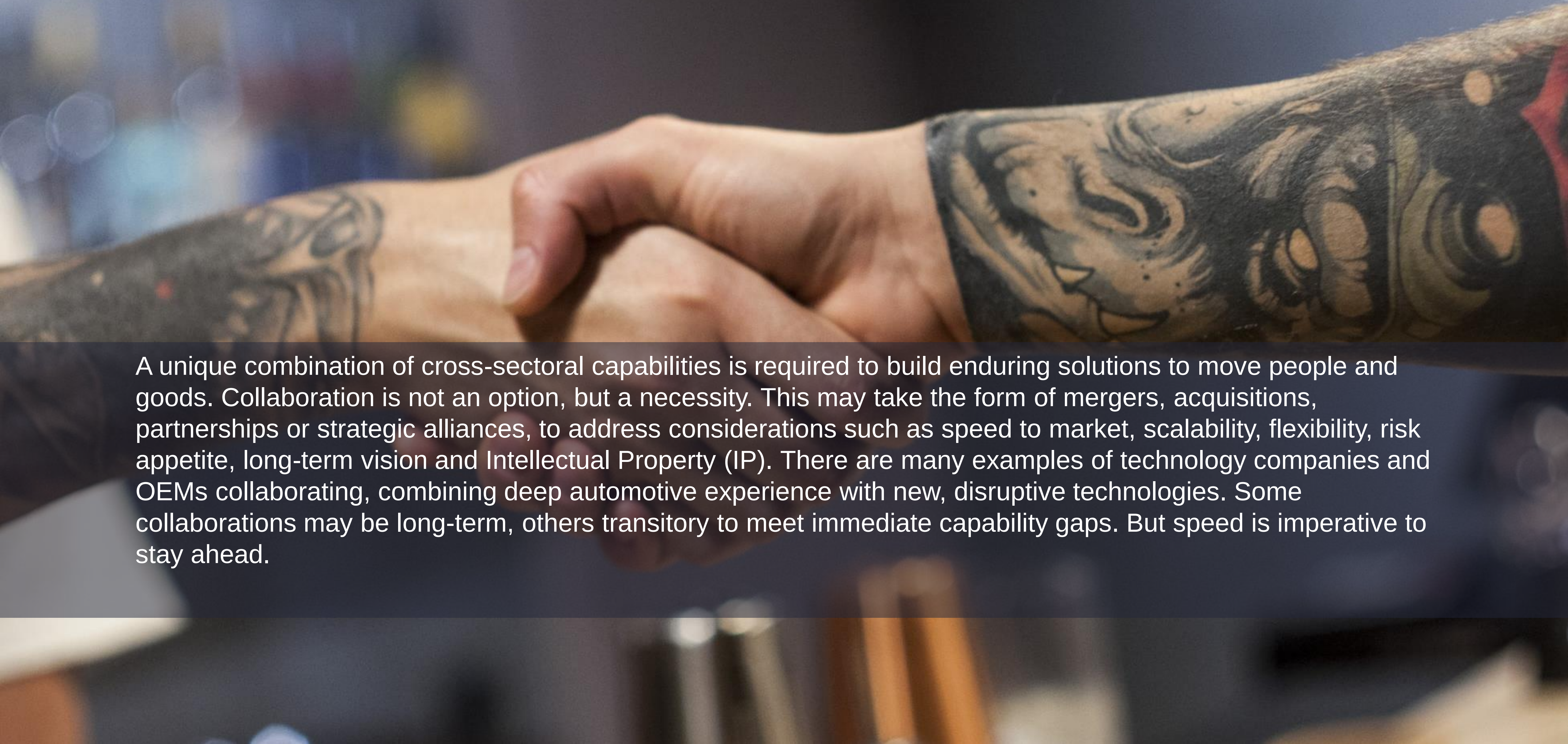
- How secure must the data be?
- Private data can be accessed by unauthorized people.
- The data has a sensitive nature, and must be protected sufficiently
- Security breaches may occur
  - An example of this was a test project for Jeep where hackers managed to gain remote access of a car more than 10 miles away, through the in-car WiFi.

Fast pace of new technology

- How does regulations adopt to new technology?
- When is the new technology «bullet proof», and free of faults?
  - Requirements needed?
- In order to be taken into use, new technology must be clear on its ethical stand so that it will be adopted.

15 Information collected from Horizon 2020 Commission Expert Group to advise on specific ethical issues raised by driverless mobility (E03659) *"Ethics of Connected and Automated Vehicles, Recommendations on road safety, privacy, fairness, explainability and responsibility"* (2020)

Partnerships and ecosystem in the automotive industry



A unique combination of cross-sectoral capabilities is required to build enduring solutions to move people and goods. Collaboration is not an option, but a necessity. This may take the form of mergers, acquisitions, partnerships or strategic alliances, to address considerations such as speed to market, scalability, flexibility, risk appetite, long-term vision and Intellectual Property (IP). There are many examples of technology companies and OEMs collaborating, combining deep automotive experience with new, disruptive technologies. Some collaborations may be long-term, others transitory to meet immediate capability gaps. But speed is imperative to stay ahead.

There are many consortiums and forums where the private and public sector are working together on the topic of connected vehicles

ADAC: Allgemeiner Deutscher Automobil-Club

Europe's largest motoring association. The object of ADAC is “the representation, promotion and advocacy of motoring, motorsport and tourism interests”. Founded in 1903, and currently has 21.2 million members. Delivers road side assistance, distributes maps, operates driver safety centers and more.

Data Task Force

Aim to improve road safety by maximizing the reach of safety-related traffic information powered by safety data generated by vehicles and infrastructure. Established by European Commission, All European Transport Ministers and several industry partners in 2017.

5G Automotive Association

Was created to connect the telecom industry and vehicle manufacturers to develop end-to-end solutions for future mobility and transportation services. Created in 2016 by vehicle manufacturers and telecommunication companies. Offer membership, and does currently have more than 130 member companies.

GENIVI Alliance

Develops standard approaches for integrating operating systems and middleware present in the centralized and connected vehicle cockpit. Connects adopters with suppliers resulting in a collaborative community of 100+ members worldwide. Founded 2009.

Car Connectivity Consortium

Aim to advance technologies for smartphone-to-car connectivity solutions. Launched in 2011 by eleven global companies across several industries. Represent a large part of the smartphone- and vehicle industry, with more than 100 member companies.

AutoMat

The core intention is to establish a novel and open ecosystem in the form of cross-boarder vehicle big data marketplace that leverages currently unused information gathered from vehicles. Aim to be OEM-independent.

Open Automotive Alliance

Aim to bring the Android platform to cars. Alliance of technology and auto industry leaders. Founded in 2014.

Car 2 Car Communication Consortium

Aim to assist towards accident free traffic at the earliest possible date. Consists of leading international vehicle manufacturers, equipment suppliers, engineering companies and road operators. Founded in 2002 by vehicle manufacturers with the objective of developing European standards for C-ITS.

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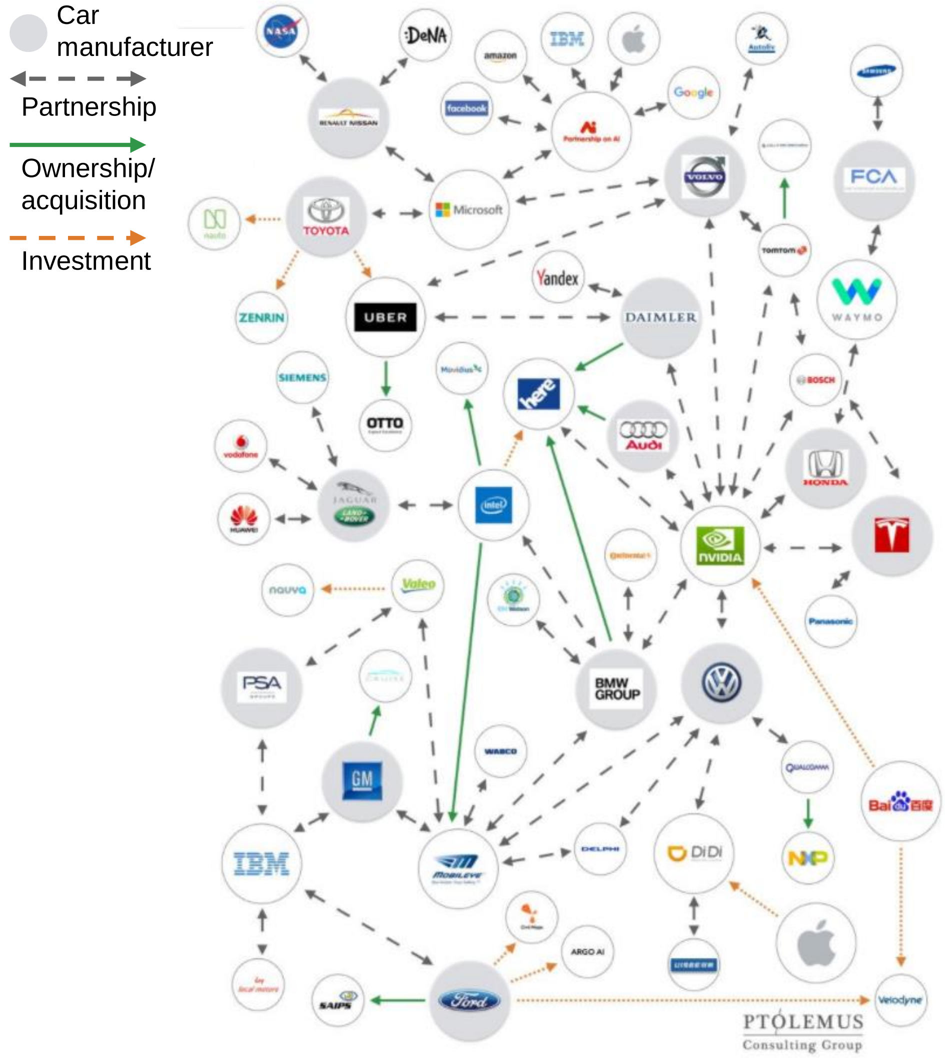
The OEMs and technology providers are collaborating in an extensive ecosystem

Creating value from vehicle data and solving customer problems require a broader set of perspectives. By establishing partnerships and connect to the ecosystem OEMs are able to bring together a broader set of capabilities. Forward, the OEMs and dealers needs to continue to expand their understanding of customer journey beyond the brand, by incorporating the whole customer ecosystem for more personal experiences.

The partnerships, ownerships, and investments within the this ecosystem are volatile and dynamic, and the figure from 2017 by PTOLEMUS Consulting Group are already somewhat outdated. However, it present the complexity in the ecosystem in a good way, and many of the partnerships are still present and expanded. It shows that OEMs are cooperating with technology players and digital disruptors across industries, and already in 2017 about one third of OEMs were partnering with digital disruptors.

Digital disruptors and other service providers have capabilities the OEMs lack, and can build services to increase customer experience based on vehicle generated data. Their development and position in the market are, however, determined by the infrastructure and data exchange by OEMs. The good news are that sharing and working together will have a great potential for providing not only significant benefits for the customer, but also generate new revenue streams for OEMs form data sharing, and generate income for service providers and digital disruptors as they are able to utilize the data to create new services and products. This can have benefits in the automotive services, in addition to related and non-related industries as this enables companies to harnessing new technologies across business verticals.

As the extensive car manufacturer and technology players ecosystem are enabling a large amount of openings for new revenue streams some new considerations needs to be taken into account, especially cybersecurity related issues. A closed vehicle system is much easier to secure than a connected ecosystem, because of increased points of entry and increased communication. Also, the responsibility of the data is more complex when connected to an ecosystem. The OEM will be responsible to the customer for the use and distribution of data, at least in the near future. Hence, the ecosystem requires clear boundaries and defined data hand-offs to maintain trust and integrity of the data, and between customers and players in the ecosystem.



The road to autonomous driving

Connected and Autonomous Vehicles (CAVs) offer an opportunity to transform the world by fundamentally altering the way people and goods are moved. It could improve safety and congestion, while opening up independent mobility to excluded people such as younger or older travelers. It could also increase productivity, bring a new travel experience, change the roles of future employees and free up valuable urban land like parking lots.

Momentum towards highly automated (Level 4) connected vehicles continues apace. At least 15 OEMs have pledged to release Level 4 AVs between 2019-2025, where much of the early deployment are expected to be in urban areas. Alphabet subsidiary Waymo has already formally launched its commercial self-driving car service in Arizona[16].

Level 5 autonomy – full autonomy in all locations and conditions – may not arrive before 2030, and even this may be unrealistic. The market is instead launching iterations of Level 4 autonomy, gradually expanding the areas where such vehicles can travel. Even though the technology is maturing at a rapid pace, regulations and legislations will have to follow to allow fully autonomous vehicles on the roads.

Levels of automation as defined by the automotive industry

0 **No Automation**
Driver performs all driving tasks

1 **Driver Assistance**
Some assist features may be included in the vehicle design

2 **Partial Automation**
Vehicle has combined automated functions, but the driver must remain engaged with driving tasks and monitor the environment at all times

3 **Conditional Automation**
Driver is a necessity, but not required to monitor the environment and be ready to take control of the vehicle

4 **High Automation**
The vehicle can perform all driving functions under certain conditions and the driver may have the option to control the vehicle

5 **Full Automation**
The vehicle is capable of performing all driving functions in all conditions. The driver may have the option to control the vehicle

Levels of automated driving

The level of car autonomy is defined by a set of increased capabilities and complex technologies. The J3016 standard[17] defines six levels of driving automation, from SAE Level Zero (no automation) to SAE Level 5 (full vehicle autonomy). It serves as the industry's most-cited reference for automated-vehicle (AV) capabilities.

The levels listed on the left is a simplified example of the SAE defined levels of automation.

"We overestimated the arrival of autonomous vehicles," said Ford's chief executive officer Jim Hackett in April 2019, adding that the company's first AV was still planned for 2021 but *"its applications will be narrow, what we call geo-fenced, because the problem is so complex"*

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There are multiple forces driving the development towards autonomous driving, and OEMs are re-structuring to be a part of the self-driving future

Forces driving the development of autonomous driving

- For mobility providers, such as Uber and Lyft, autonomous driving are an important area. This will enable them to fulfill their business model in making transportation easier, more efficient and cheaper for everyone by significantly reducing their cost base when eliminating cost of driver. Hence, these players will work hard to push other parts of the ecosystem to speed up the pace in reaching fully autonomous vehicles.
- Studies of customer expectations shows that customers are expecting increased AV-features in their cars, and are willing to switch brand to fulfill this wish[18].
- As autonomous vehicles are expected to transform the traditional ways we think about driving and mobility, many OEMs are currently challenging their traditional business models to be able to capture first mover advantage of the new and transformed mobility market[19].

How are OEMs approaching autonomous driving

- At least 15 OEMs have pledged to release level 4 autonomous vehicles within 2025, with much of early deployment expected to be in urban areas.
- Level 5, full autonomy, is not expected before 2030.
- However, some OEMS does not focus as much on level 5, and think Level 3 is sufficient for their customers. Offer a product with greater value for the customer. Examples are driving assistants, route optimization, automated parking systems and in-car entertainment.
- Autonomous driving threatens the very existence of mid-level automakers as the market develops along three segments: premium, low-cost, and drones[19].

What are the enablers to succeed with autonomous driving in near and long terms

- **HD mapping** provides a 360-degree view of the roads and driving conditions, and thus HD-maps are an enabler for self-driving cars to make faster and more precise decisions with the AD-systems that are already in place. HD-maps are also important to handle extreme weather conditions.
- **Communication**: There is debate as to what degree OEMs will utilize digital infrastructure for AVs, including sensor networks, roadside equipment such as smart traffic lights, as this both increase the risk of cyber attacks and increase risk of failure due to dependency on network connection. From a safety point of view, level five AVs should not need to rely on external infrastructure to operate, but it is an enabler for lower levels of autonomy.
- **Geofencing**: the use of geofencing will enable different levels of autonomous driving in certain areas with a geographical limitation.

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Ongoing projects are tested in closed or controlled environments

Around the world there are a number of ongoing projects piloting self driving vehicles. There are several Nordic companies involved in such projects. Below are some examples on Norwegian roads and with Nordic companies.

APPLIED AUTONOMY

Offers services for piloting and testing of autonomous traffic. Among others, currently operating one bus at Svalbard and one bus in Kongsberg. Continuously improving sensors to meet challenges caused by weather.

SCANIA + RioTinto

Testing a new generation autonomous transport system at Rio Tinto's Dampier Salt operations in Australia. Started in 2018 with a control driver in the truck, and aiming to make this autonomous in the future.

Ruter# + holo

Since 2019 trialing self-driving vehicles as an integrated part of the public transportation in Oslo. The pilot project collaboration between Ruter and Holo is one of the largest in its category with 27 000 + passengers and 21 0000 kilometers travelled (per august 2020). Currently driving with a control driver.

Operational pilot projects with autonomous vehicles. Holo is the largest operator in the Nordics and Baltics with more than 30,000 km travelled. Currently operating pilots in four different locations, with more to come.

BRØNNØY KALK + VOLVO

Volvo trucks are currently operational in the mines Brønnøy Kalk in Norway. The autonomous trucks are driving five kilometers before dumping the load, all on their own. Volvo delivers this as a service they call hub-to-hub.

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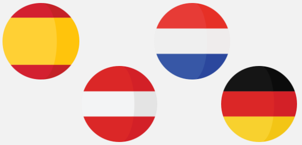
Chapter 4:

The Authority Perspective

Chapter 4: The Authority Perspective on Data Sharing in the Automotive Industry

In this chapter we will outline the authorities perspective on data sharing in the automotive industry. Authorities have an important role in the industry of automotive data sharing, and will in many countries be an enabler for secure and efficient data exchange. Authorities are motivated to take an active role as they also have a huge potential in utilizing vehicle generated data more extensively.

1. Key takeaways from qualitative studies
We will present the key takeaways from the qualitative research we have done by interviewing stakeholders in the automotive industry.



2. National Access Points and country profiles
In this section, we look at the regulatory requirements for the NAPs, and dive into the platforms in Spain, Austria, the Netherlands and Germany. We will explore what data they are ingesting and sharing and how they are using their data.

3. Regulations, directives and standards for data sharing and data exchange
A selection of the relevant regulations, directives and standards on a global and European level will be presented.

4. Data standards and metadata catalogue
A quick look into the work that is currently being done on standardization and interoperability to make data exchange even easier.

5. Use cases from the authorities perspective
We will outline a selection of use cases for vehicle generated data that are beneficial for authorities to provide an understanding of the great potential.

6. Cost of data acquisition
We will present the different approaches to data acquisition and the benefits, challenges and costs that will be related to the respective approaches.

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The authority perspective - key takeaways from our qualitative research

NRAs are improving road safety and quality through vehicle generated data

There are ongoing initiatives related to the usage of vehicle generated data in a number of countries. The most proactive approach we have seen is that of DGT in Spain, which is building their own Connected Vehicle Platform to take a holistic approach in order to support their Zero vision; zero deaths, zero accidents, zero emissions.

Accessing car data is becoming easier through data aggregators, and we've seen several examples of ministries or NRAs putting out tenders for the access to car data. An example of this is Rijkswaterstaat, where a data aggregator won the tender to be the provider of aggregated vehicle generated data to NDW – the National Access Point in The Netherlands.

A need for cross-country collaboration in building a distributed network of access points for location based vehicle generated data has been highlighted by several NRAs. Some examples on how they are collaborating will be highlighted in later in this chapter.

Multiple NRAs are highlighting the need for open and standardized formats, which is being worked on both on an EU and UNECE level. In the Data Task Force, they have agreed on standards for data exchange formats to be used by all consortium members. However, even though Datex II is the established format, there is still room for standardization of for example the metadata.

There are ongoing initiatives in several NRAs where they share infrastructure data with OEMs, like congestion, geofenced zero emission/EV zones, traffic light information, construction/road work information and dynamic speed limit information. The NRAs are increasingly looking to utilize vehicle generated data to improve road safety, however the OEMs are more restrictive in sharing data for more commercial use cases.

National Access Points and country profiles

According to EU Regulations 885/2013, 886/2013 and 2015/962 every EU Member State has to implement a Single Point of Access (SPA) to enable access of all relevant data within the scope of these specifications for its country. These SPAs is also referred to as National Access Points (NAP), and include safety related traffic information - among other data sources. As maturity of the NAPs are increasing, the responsible governmental bodies are looking to include more vehicle generated data into their NAPs. We already see examples from DGT in Spain, NDW in Netherlands and MDM in Germany on pilot projects with V2I-communication facilitated by national access points.

In this section, we will dive into the national access points from Germany, Austria, Netherlands and Spain. We will explore what data they are ingesting, what data they are sharing and how they are using their data.

Several European authorities have taken an active role to provide traffic information to road users

In Europe the authorities have taken quite similar approaches to accessing and using vehicle generated data, where the authorities have taken an involved and active role in the ecosystem. There are, however, some variances in the approaches they have taken. While some authorities' are developing new platforms for this purpose, others have chosen to utilize existing data platforms to gather, access and using data. Further we will elaborate on the approach of four chosen European countries.

- The Spanish NAP is a real-time connected vehicle platform aiming to interconnect the mobility ecosystem in Spain
- Fully interoperable ecosystem, leveraging open standards, aligned with European Data Task Force proposed formats and data guidelines and policies
- Multiple use cases will be available to public usage in 2020
- Ongoing V2I pilot projects (e.g. DGT/SEAT)

- The Austrian National Access Point (NAP), also known as Mobility Data Platform, offers public and private organizations the opportunity to present and advertise their mobility-related data.
- Mobility data from private and public organizations are collected here in order to generate an overview and to make data access easier.
- Investigating the opportunity to push data into vehicles

- The Dutch NAP is established as a National Data Warehouse (NDW) that deals with traffic data. Different types of data arrive at NDW from many sources. This data is merged, stored and then distributed to customers.
- The authorities have framework agreements with multiple service providers, giving them access to vehicle generated data.
- Actively engaged in the Data Task Force through RDW and Rijkswaterstaat

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- Authorities in Germany has established a Mobility Data Marketplace (MDM), a central online portal that provides traffic data. The simplified exchange of data with third parties and access for private service providers supports new possibilities in the field of traffic management and service offerings.
- Ongoing V2I-initiatives (e.g. Hessen/Mercedes)
- Together with Austria and the Netherlands a part of a standardization working group connected to metadata in relation to the Delegated ITS Acts.

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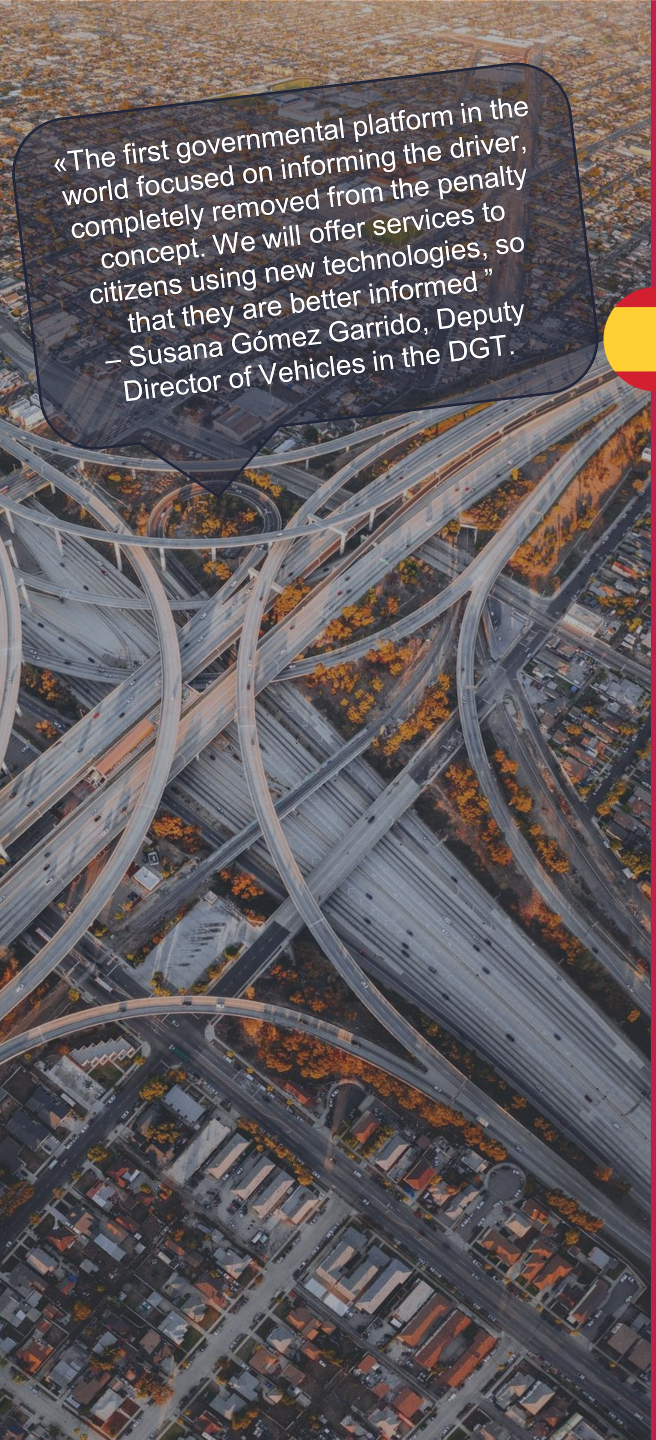
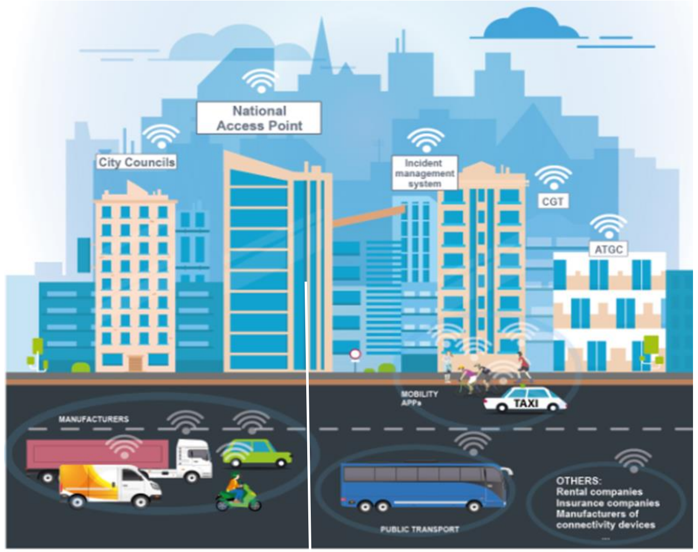


Spain's approach to enable automotive data sharing

Spain

In may 2018 Spain started a project called DGT 3.0 Connected Vehicle Platform. The project aims to increase traffic safety by developing a technological platform for data exchange and V2I-communication.

In short the platform provides anonymized, real-time and contextualized data to interconnect the mobility ecosystem. They are aiming for full national coverage, and European projection as they are a pioneer in Europe with this extensive project. The project is aligned with the European ITS-strategy, and data exchanges are aligned with European Data Task Force proposed formats, data guidelines and policies. Hence, they are establishing a fully interoperable ecosystem, leveraging open standards. The data will be free of charge, and collecting and provides official and non-competitive information.



What data are they sharing?

Both static and dynamic road data, the list is not exhaustive, but examples:

- Safety related traffic information (STRI)
- Traffic map and mobility maps
- Real-time traffic information
- Adverse weather conditions
- Dataset provided by TomTom including real-time traffic data, SRTI and dynamic road data
- Data on incidents and hazard warnings
- Cameras, panels and radars

What data are they ingesting?

- Safety Related Traffic Information licensed through Data Task Force
- OEM data directly through OEM APIs for specific pilot projects
- Here Technologies' aggregated data
- DGTs own sensors (e.g. cameras) placed around the road network
- TomTom location based data

How are they using data?

The overall goal of DGT 3.0 Connected Vehicle Platform is to reach the Zero ambition; 0 dead, 0 injured, 0 congestion, and 0 emissions, on Spanish roads. Use cases include:

- Real-time traffic light information
- Information about roadworks in real-time
- Information shared by users like broken down vehicle, obstacles, accidents, bad weather etc.

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Spain's National Access Point- DGT 3.0 Connected Vehicle Platform

Spanish National Access Point

The DGT 3.0 platform is receiving data from multiple data sources, process it and make it available to car manufacturers and public service operators. They receive messages with status of the traffic lights, their phase changes and topological information. These will in turn offer vehicles individualized information in real time. The goal is that this will:

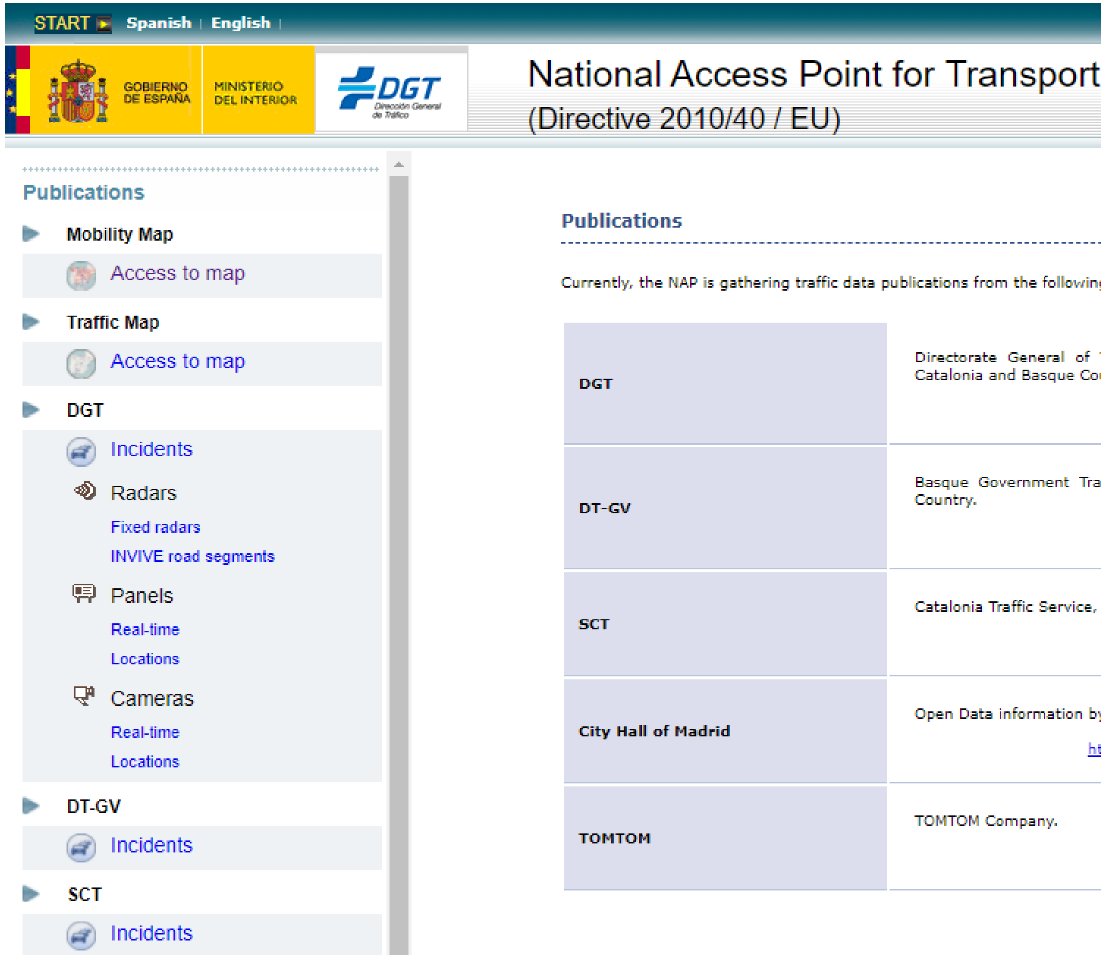
- Improve the driving experience for the sake of better road safety and mobility
- Improve route planning and public service operations.

To be able to do this the Spanish authorities have made agreements with 5 different data providers, including Here Technologies and TomTom.

Currently DGT are running an I2V-communication pilot project together with Telefónica and SEAT where they are exploring the opportunities for increasing traffic safety for cyclists. The aim of the project is to show how V2X-communication with low latency can work for early detection and warning of hazards to drivers travelling on a road with two specific cases that often cause situations of great danger:

- The presence of a cyclist riding along the same road
- The existence of a stationary car on the road due to a breakdown or some other type of incident

These kind of use cases are made available through the DGT 3.0 platform, and Spanish authorities are aiming for start utilizing the platform to fulfill even more use cases during 2020.



Architecture of the DGT 3.0 Connected Vehicle Platform

The main elements of the DGT 3.0 platform

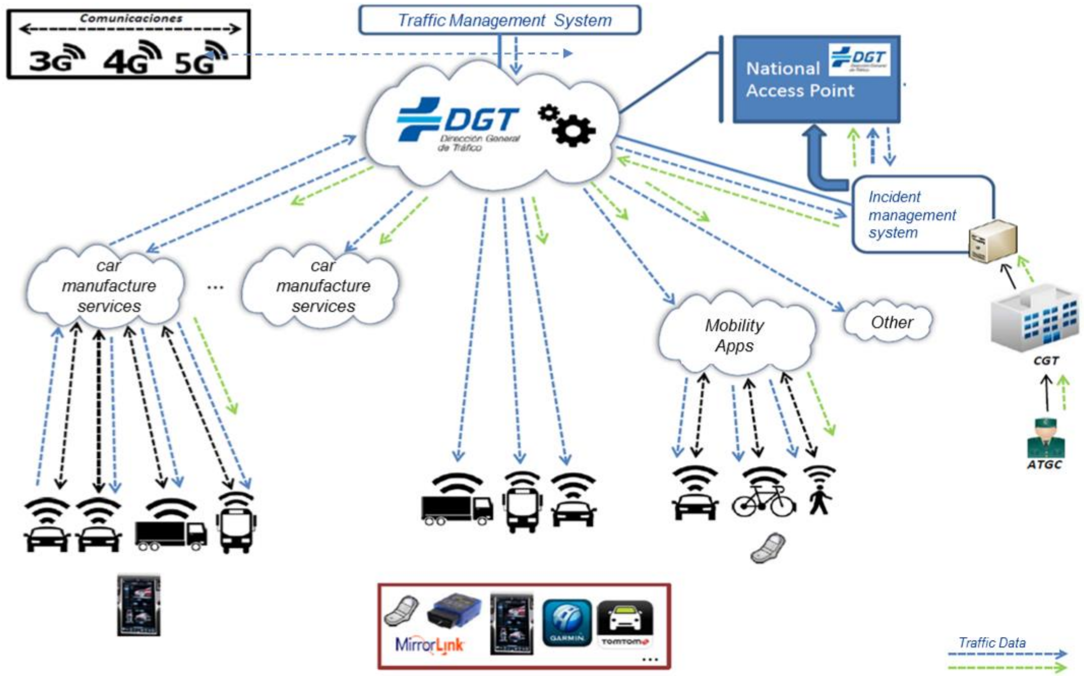
Reception of data

- The minimum data requirement consists of coordinates and events detected automatically by the vehicle or manually by the citizen.
- Example of events detected automatically are activation of windshield wiper, fog light or ABS. Events seen by the driver can include accidents, dense fog and breakdowns.
- This data can be dispatched directly from the vehicle itself, or through an intermediary like an app provider, service provider or the driver’s smart phone.

Processing and forwarding of data

- The processing of data transforms it into data usable for citizens.
- Considering the use cases defined by the DGT, the processed data can determine if there is anything affecting the roads of a specific point or area of the road network.
- Citizens who will be affected by the incidents, either by being in the area, or having a planned itinerary in the area, will be alerted. This will encourage planning and avoid a surprise effect, thus reducing accidents, traffic jams and therefor emissions.
- Disclosure of information in real time will send alerts either directly to the vehicle or through and intermediary.
- In this way, DGT has an overview of the road network, and can get ahead of what is occurring, and thus resulting in an intelligent management of traffic.
- To not overload the communication lines, only the necessary information for the purpose will be collected. Due to speed, processing capacity and other factors, the information must be distributed in an agile way without neglecting the importance of security.
- Protection of privacy must be guaranteed, and the vehicle data must be dissociated so that the identity of the data subjects remains anonymous.

20 Information collected from *“Pliego de Prescripciones Técnicas – Plataforma de Vehículo Conectado DGT 3.0“* (2016)



Main features

- ❑ Request information according to their needs
- ❑ Logic that allows for exploiting the available information and inform users
- ❑ Data consumption at a minimum level for DGT

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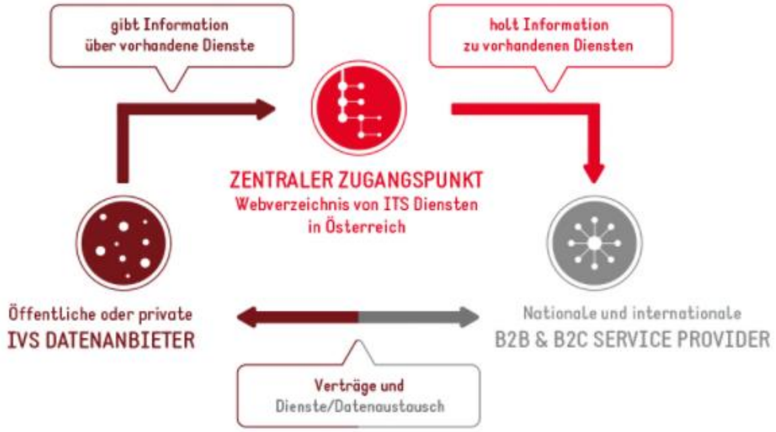
Austria's approach to enable automotive data sharing

Austria

The Austrian National Access Point (NAP), also known as Mobility Data Platform, offers public and private organizations the opportunity to present and advertise mobility-related data. Mobility data from private and public organizations is collected in order to make data access easier and to provide and an overview. The Mobility Data Platform also serves to forward data from static truck parking space information to the European data portal as part of the "Safe and secure truck parking"-initiative.

The Mobility Data Platform is operated by AustriaTech, as a neutral body. The project is partially financed by the INEA (Innovation and Networks Executive Agency) .



What data are they sharing?

- 24 datasets, including: Real-time traffic data, Traffic restrictions, Dynamic traffic restrictions, Road conditions and unexpected events, Safety related traffic information, Static road data, Toll information, Freight and logistics, Truck parking information, Parking information, Tank and charging stations, Data for location information services, Data for information services, Data for dynamic travel calculations, Data for dynamic information services

What data are they ingesting?

- Data from 7 providers, including AustriaTech, ÖBB, FlixBus, TomTom, ÖAMTC, ORF/OE3 traffic editing, ASFINAG
- Cameras provide information about vehicle count and speed.
- Safety Related Traffic Information licensed from Data Task Force is used in a pilot to learn how to utilize this data in an efficient manner
- Environmental data: snow, ice for salt distributing

How are they using data?

- "Roadworks Warning" and "Hazardous Location Notification", "In-Vehicle Signage" including "Protected Zones"
- Plans to support services from the "Day 2"-services to assist automated driving. These services deals with topics like route clearance, distance gaps, platoon support, vehicle type and/or lane specific speed recommendation but also broader issues like collective perception of objects or persons on the road or GNSS enhancement.

21 Data collected from AustriaTech 2020

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Austria's National Access Point

Austrian National Access Point

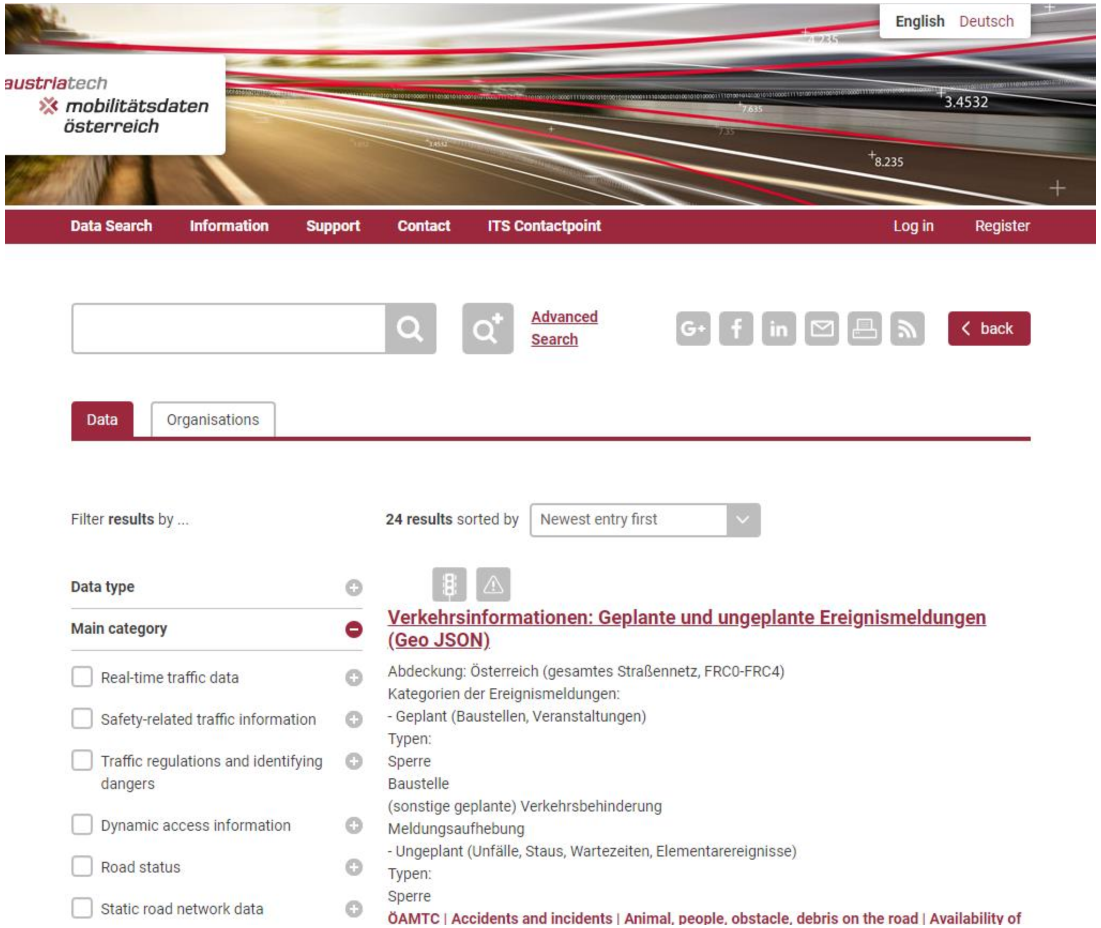
The Mobilitydata.gv.at platform serves as national Access Point of Austria for mobility data. This is an implementation of the national ITS-law.

The platform is a centralized one-stop-shop to significantly simplify the connection of local data providers and international service providers by granting access to information on existing data and use conditions (metadata).

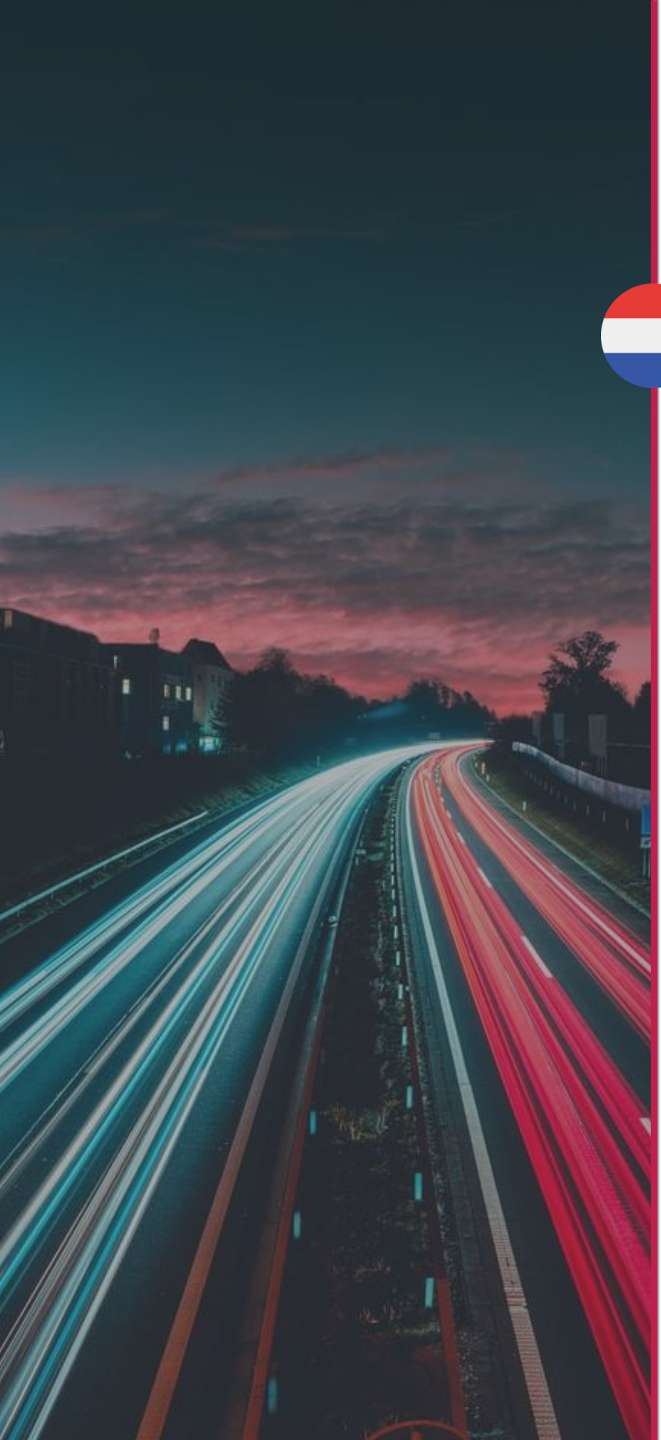
The platform has extensive reach and use with:

- Providing 24 data sets
- Ingesting data from 7 data providers
- 735.931 search request

The platform helps service providers improve the data quality of their services. Data providers can use the platform mobility data from the national access point as simple data store for pull operations, in addition to upload complete datasets, and the possibility to save costs for own IT-infrastructure and web applications. They cooperate with local data portals to ensure a maximum spread of information.



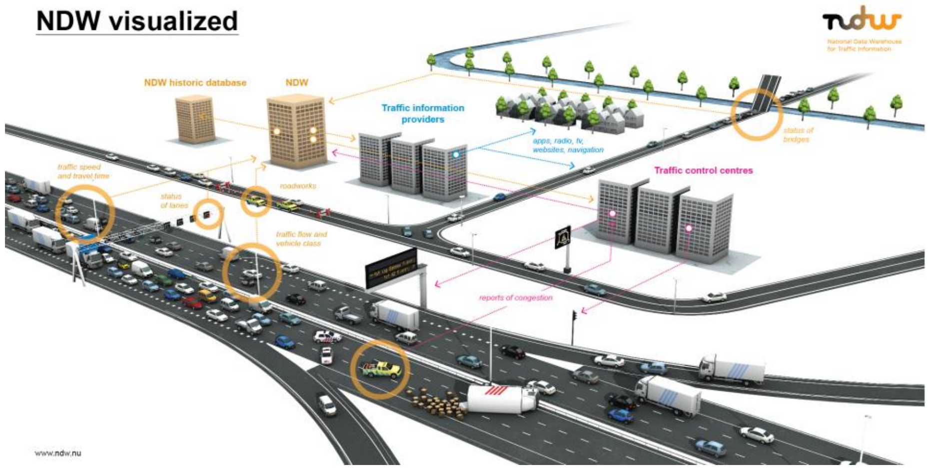
21 Data collected from AstiraTech



The Netherlands' approach to enable automotive data sharing

The Netherlands

In the Netherlands there is established a National Data Warehouse (NDW) that deals with traffic data. Different types of data arrive at NDW from a large number of sources. This data is merged, stored and then distributed to the customers. The road authorities uses the data to adjust traffic from their traffic control center with ramp metering installations, route information panels and other traffic management instruments. Service providers such as ANWB, Traffic Information Service and INRIX inform and advise travelers before and during the journey via radio, TV, websites, apps and navigation systems. The historical data is used for traffic analysis.



What data are they sharing?

Real-time traffic information such as traffic flow, realized travel time, estimated travel time, traffic speed, vehicle classes. In addition they share information such as:

- Road works and event-related traffic measures, reports on congestion, accidents and incidents, safety-related announcements such as wrong way driver, status of bridges
- Truck parking overview, safety related traffic information, road and traffic data as well as multimodal travel information

What data are they ingesting?

- More than 24 000 measurement sites in the Netherlands collects data every minute
- Planned and current road works on all roads
- >1 million digital signs
- Floating car data
- Safety related traffic information licensed through Data Task Force

How are they using data?

The open data is used in a number of different applications. The applications can be grouped into three groups:

- Traffic information
  - For example: HERE Traffic, BeMobile and IsTheBridgeOpen.nl.
- Traffic Management
  - Be-Mobile Traffic Monitoring
- Policy and research
  - NH WegWerkPlanner

22 Information collected from NDW

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The Netherlands' National Access Point

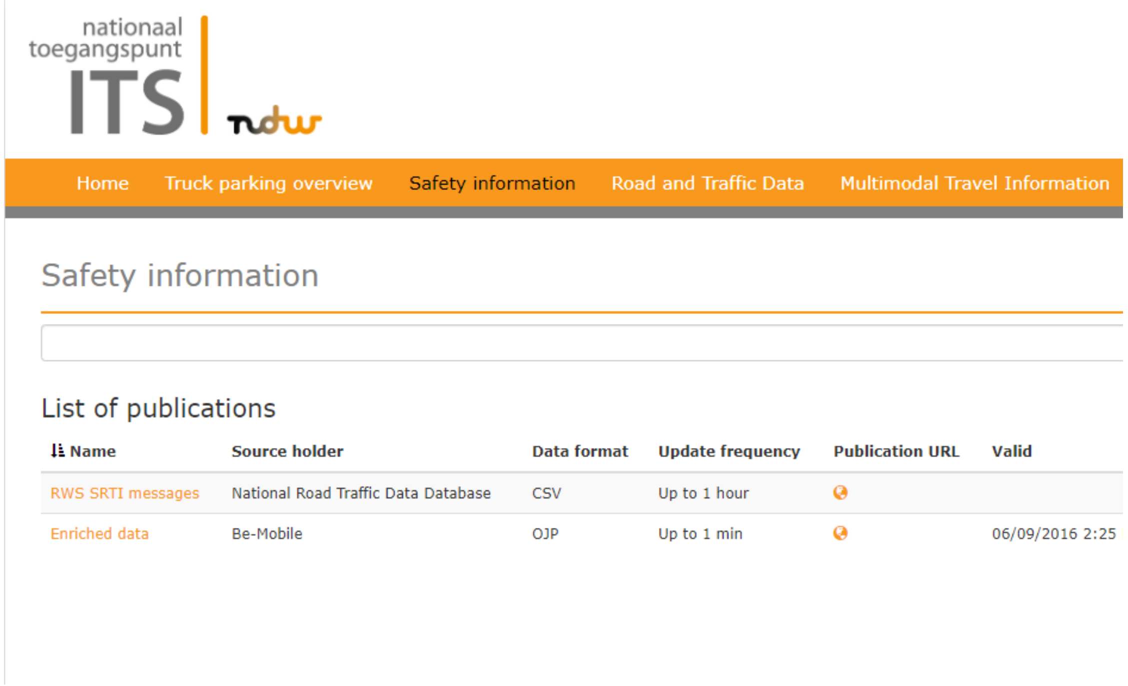
Dutch National Access Point

In the Netherlands the national access point is a cooperation between the Ministry of Infrastructure and Water Management (Rijkswaterstaat) and the Netherlands Vehicle Authority (RDW). The ITS-legislation has been 'translated' into Dutch regulation by Rijkswaterstaat, and the National Data Warehouse for Traffic Information (NDW) manages the National Access Point ITS. RDW has been designated as a supervisor for this project[22].

NDW has, together with DOVA and the MaaS-program in the Netherlands, the responsibility for setting up the NAP Multimodal. The access point will provide an overview of all data sources about and related to public transport, target group transport and the bicycle.

Data is made available in DATEX-II format, and the access point currently has the following data clusters:

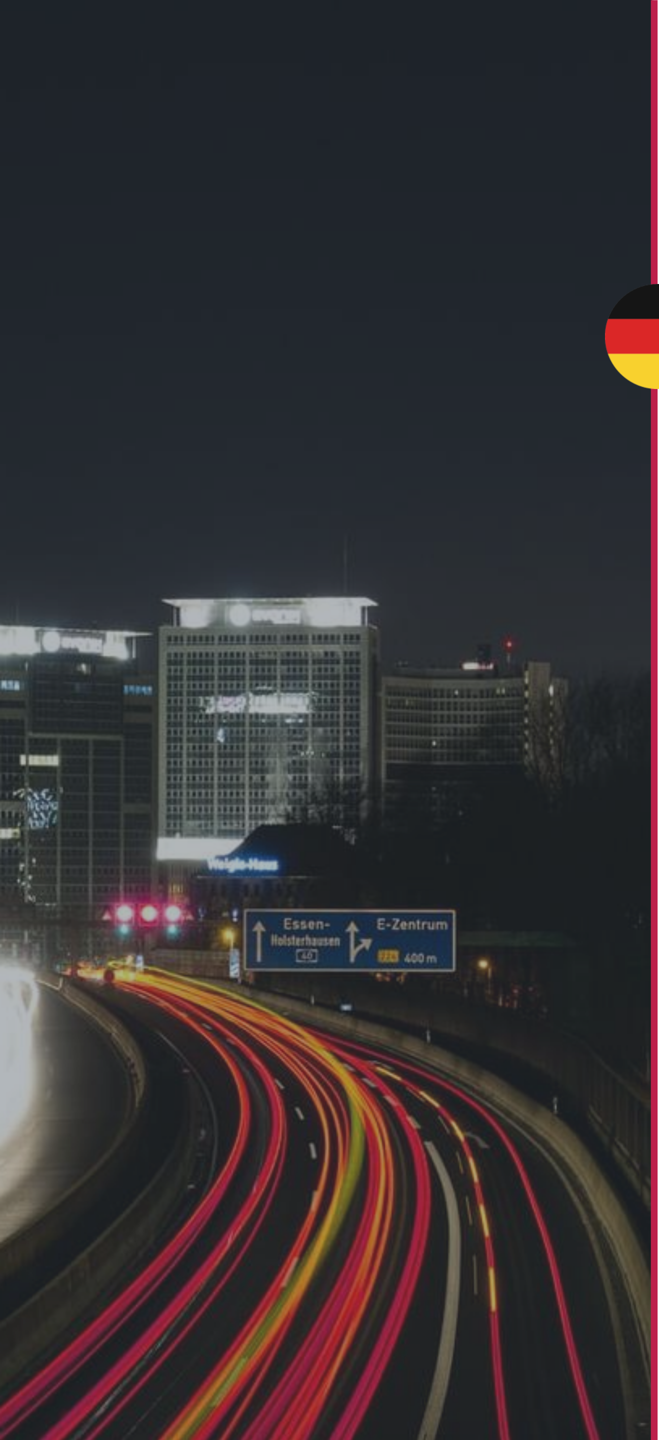
- General traffic data
- Data related to road safety
- Data on parking facilities for trucks
- Charging point data



Name	Source holder	Data format	Update frequency	Publication URL	Valid
RWS SRTI messages	National Road Traffic Data Database	CSV	Up to 1 hour		
Enriched data	Be-Mobile	OJP	Up to 1 min		06/09/2016 2:25

22 Information collected from NDW

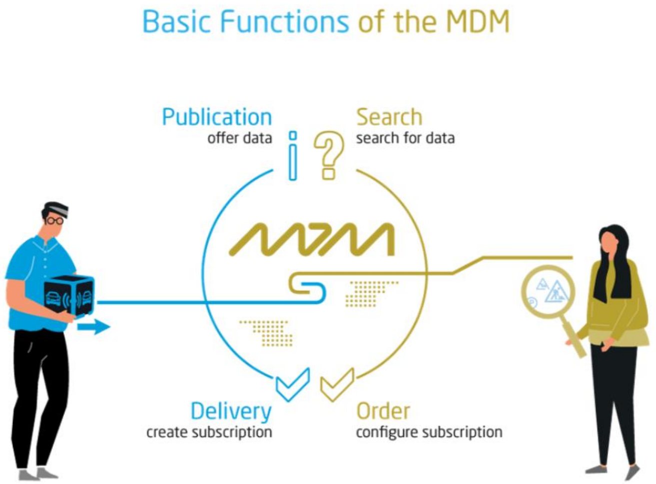
Germany's approach to enable automotive data sharing



Germany

The authorities in Germany has established a Mobility Data Marketplace (MDM), a central online portal that provides traffic data. The simplified exchange of data with third parties and access of private service providers open up new possibilities in the field of traffic management and service offerings. The MDM is one platform for data exchange in Germany, however, there are other ongoing projects utilizing DSRC for V2I-communication as well. Germany is home of several global OEMs and hence, a natural testing environment for innovative solutions.

Long before autonomous and highly automated vehicles will reach a relevant market share, large interconnected vehicle fleets will be present on German roads. Together with the current and future possibilities of vehicle sensor technology, this creates enormous potential for the accessibility of data.



What data are they sharing?

- Measured values from traffic and environment detectors
- Traffic management measures
- Parking information
- Construction site data
- Hazard and event messages
- Gas station prices
- Static road network data
- Further data (weather, forecasts etc.)

What data are they ingesting?

The Mobility Data Marketplace offers data from 553 data suppliers, and ingest data on among others:

- Safety related traffic information
- Traffic management information
- Sensors and construction work information
- Floating car data

The MDM acts as a “neutral platform” for secure data exchange.

How are they using data?

Examples of use cases utilizing the MDM:

- Stuttgart: Navigate through Stuttgart in an integrated and intelligent way[23]
- Frankfurt: Well oriented in the Frankfurt metropolitan area[24]
- Hessen Mobil: Car-to-x with construction site data in real time[25]
- Dusseldorf: Automatically better informed in Dusseldorf[26]

Other projects:

- V2I-communication: Audi and TTS in Ingolstadt for traffic light information

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Germany's National Access Point

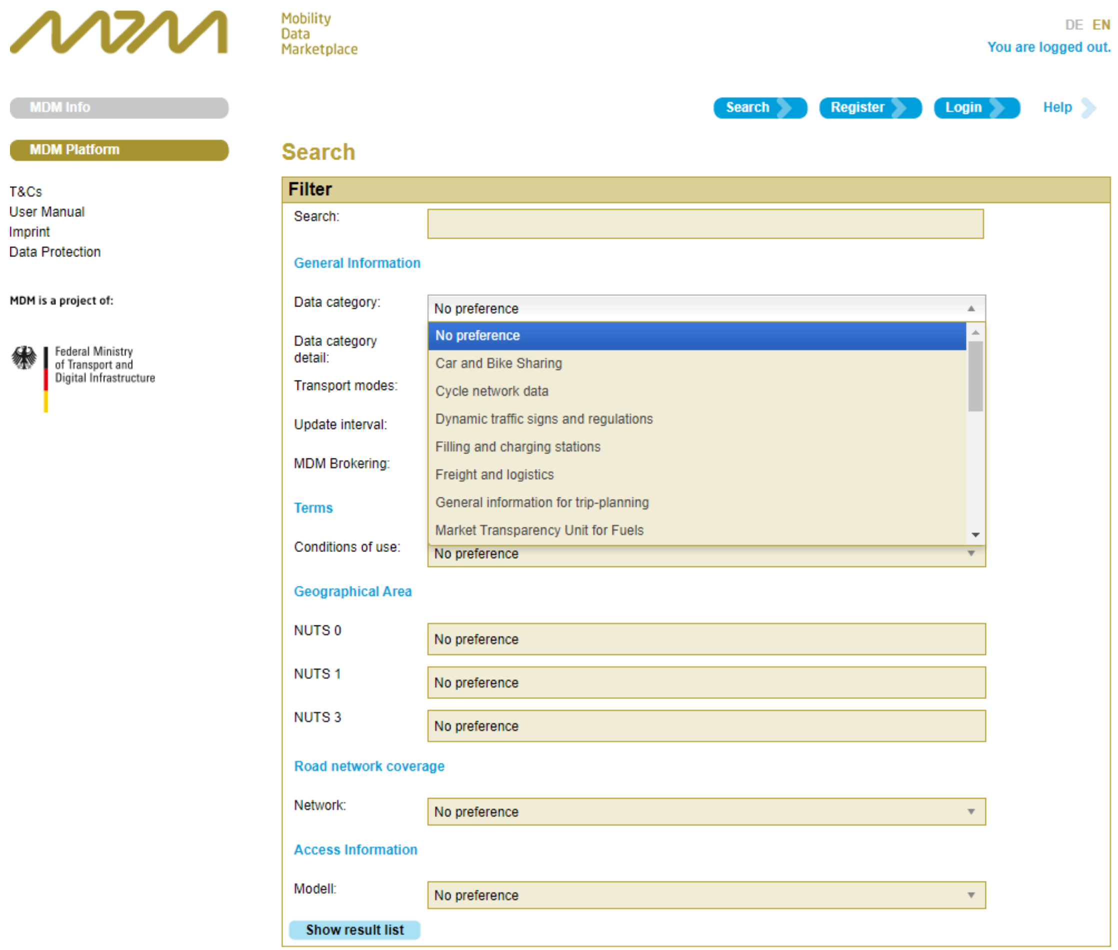
German National Access Point

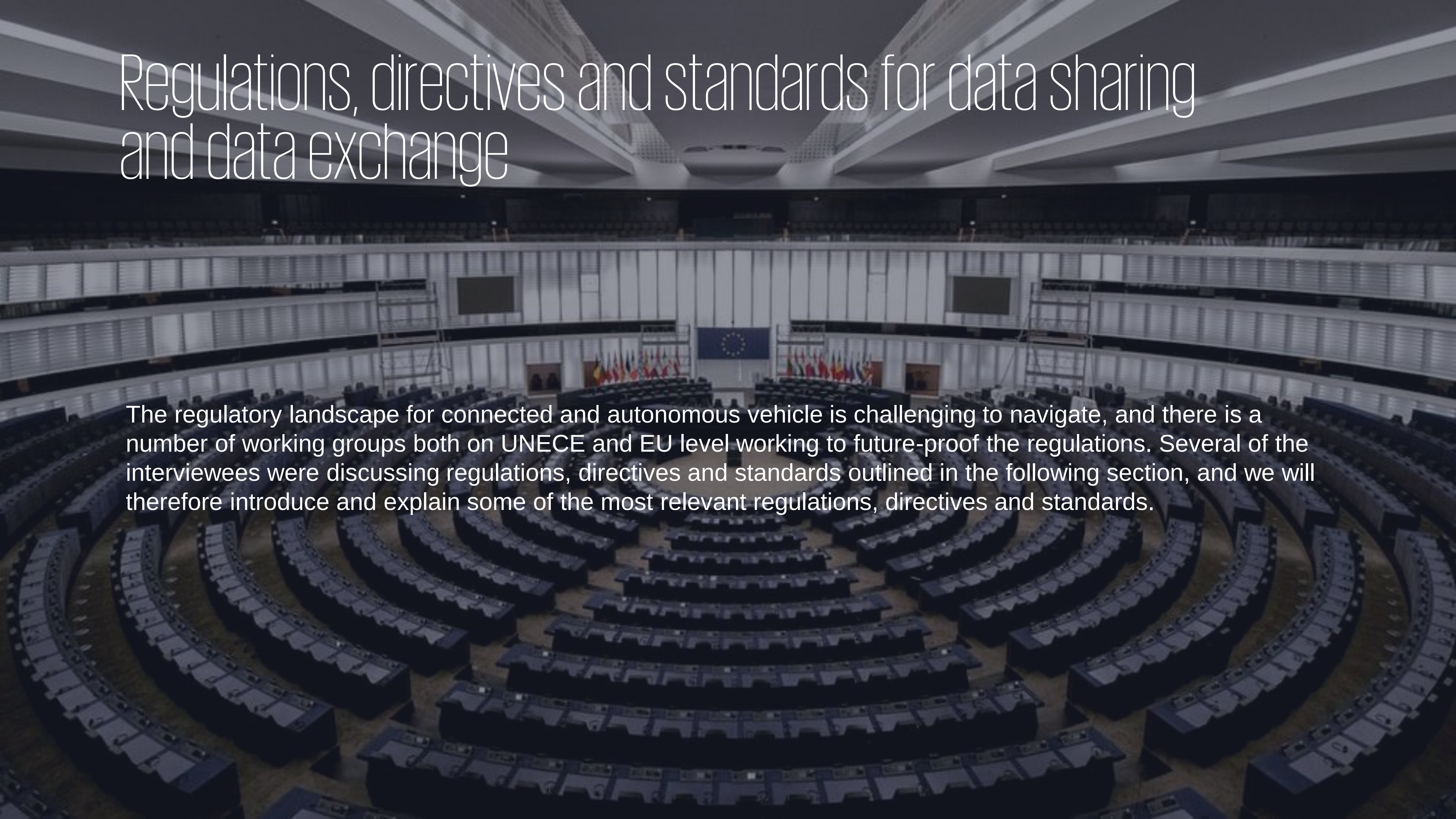
It is the Federal Ministry of Transport and Digital Infrastructure (BMVI) that is responsible for the Mobility Data Marketplace (MDM) platform in Germany. The MDM is a neutral B2B-platform, with defined standards for data exchange.

The Mobility Data Marketplace allows – via its Internet service MDM Platform – offering, searching and subscribing to traffic relevant online data, as well as the distribution of online data between data suppliers and data clients. The platform forwards the data supplied by the data suppliers unchanged to the data clients[27].

MDM has the biggest volume of information on traffic flows, traffic jams, road works, mobility options, and parking facilities in Germany.

36 000 data recipients	553 data providers	36th Millions of data packets delivered per month





Regulations, directives and standards for data sharing and data exchange

The regulatory landscape for connected and autonomous vehicle is challenging to navigate, and there is a number of working groups both on UNECE and EU level working to future-proof the regulations. Several of the interviewees were discussing regulations, directives and standards outlined in the following section, and we will therefore introduce and explain some of the most relevant regulations, directives and standards.

The most relevant regulations and standards for automotive data sharing

//Not exhaustive

UNECE LEVEL

- ISO / TC 204: Standardization of information, communication and control systems in the field of urban and rural surface transportation, including intermodal and multimodal aspects there of, traveler information, traffic management, public transport, commercial transport, emergency services and commercial services in the intelligent transport systems (ITS) field.[28]
- ISO / TC 22: in-vehicle transport information and control systems, including data communication for vehicle applications
  - Data buses and protocols, V2X communication, diagnostics, test protocols, interfaces and gateways, data formats, standardized data content[29]
- ISO 20077 and ISO 20078 on Extended Vehicles (ExVe)

EU LEVEL

- A European strategy for data: The European data strategy aims to make the EU a leader in a data-driven society. Creating a single market for data will allow it to flow freely within the EU and across sectors for the benefit of businesses, researchers and public administrations[30].
- C-ITS regulations and legislations: (EU) No 885/2013 – Safe and secure truck parking, (EU) No 886/2013 – Safety related traffic information, (EU) 2015/962 – Real-time traffic information, (EU) 2017/1962 – Multimodal travel information services. These will be explained further on next page.
- (EU) 1/2020 on processing personal data in the context of connected vehicles and mobility related applications, in addition local regulations and legislations of data privacy and security must of course be taken into account[31].

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The Directive 2010/40/EU on the framework for development of Intelligent Transport Systems outlines regulations and standards for traffic information

Delegated acts under the ITS Directive 2010/40/EU

In the framework of Directive 2010/40/EU, specifications have been adopted in order to ensure compatibility, interoperability and continuity for the deployment and operational use of Intelligent Transport Systems (ITS) for pan-European improvements.[32]

Moving towards a Single European Transport Area requires a digital layer interlinking all of the elements of transport. Building up this Digital Architecture involves open and common standards and interfaces and an efficient, but secure data ecosystem.

This is why EU Member States are setting up their National Access Points; to facilitate access, easy exchange and reuse of transport related data, in order to support the provision of EU-wide interoperable travel and traffic services to end users. The National Access Points can take various forms, such as a database, data warehouse, data marketplace, repository, and register, web portal or similar depending on the type of data concerned. In addition the NAP provide discovery services, making it easier to fuse, crunch or analyze the requested data sets.

For these purposes, data is accessible on a non-discriminatory basis, in accordance with the necessary standards for exchange and reuse.[33]

It is expected that in 2020, 90% of all Member States will have national access points, including some non-EU members, for example UK and Norway.[34]

PRIORITY ACTION	DELEGATED REGULATION	THEME	COMMON REFERENCE
(e)	(EU) No 885/2013	Provision of information services for safe and secure parking places for trucks and commercial vehicles	Safe and secure truck parking
(c)	(EU) No 886/2013	Data and procedures for the provision, where possible, of road safety related minimum universal traffic information free of charge for users	Safety Related Traffic Information (SRTI)
(b)	(EU) 2015/962	The provision of EU-wide real-time traffic information services	Real-Time Traffic Information (RTTI)
(a)	(EU) 2017/1926	The provision of EU-wide multimodal travel information services	Multimodal Travel Information Services

EC Delegated regulations and corresponding ITS Directive priority actions

Data standards and metadata catalogue

Even though the data exchanged in the Datex II format is somewhat standardized, there is room for more standardization of for example the metadata. Also, we have found that third party service providers and start up companies trying to use the data on the Datex II format find it difficult to use. In the following pages we will look at the ongoing standardization and harmonization work being done by some EU member countries.

There is room for more standardization in the current specifications of required formats in the National Access Points (1/2)

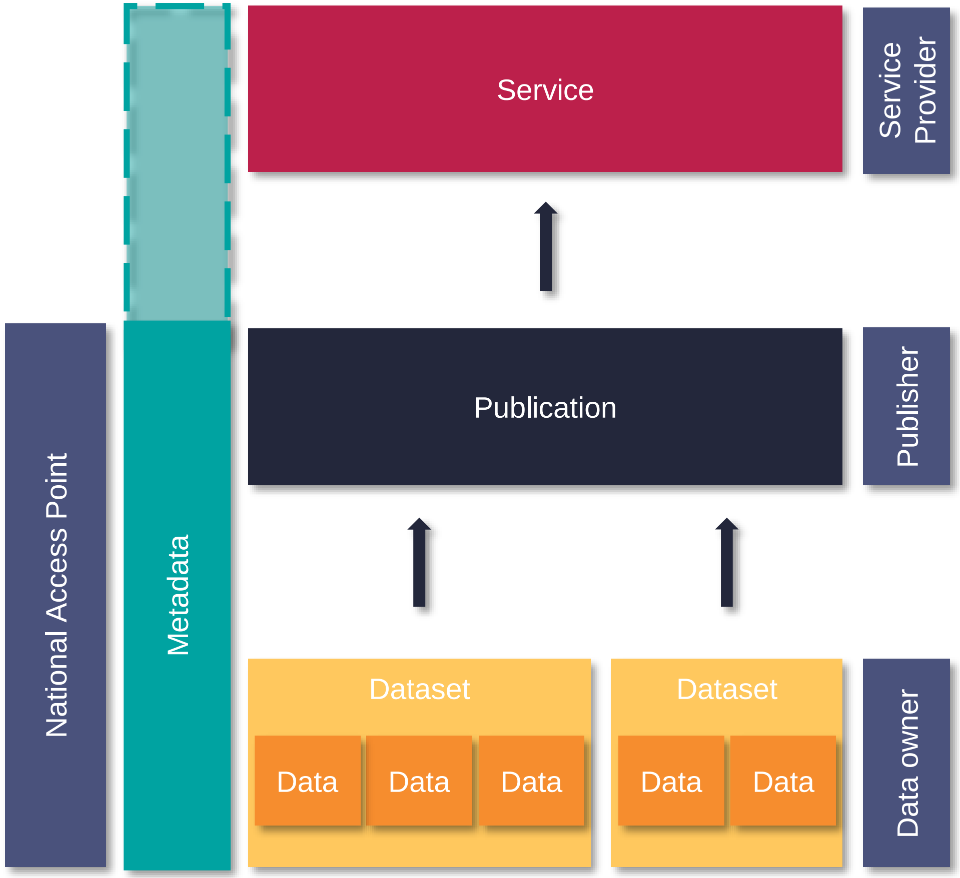
Metadata catalogue

According to EU Regulations 885/2013, 886/2013 and 2015/962 every EU Member State has to implement a Single Access Point (SPA) to data for its country.

Throughout our interview, we have found that the agreed upon standards, like Datex II, could be difficult for third party service providers to work with. The Datex II format allows information to be shared in different formats making it difficult to utilize the data even if the access is much easier. Hence, there is a need for further standardization to support cross border use of the data in national access points to increase traffic safety and enable third parties to create better services for end users.

To promote data exchange, compatibility and interoperability the Netherlands, Germany and Austria started a working group to develop a common minimum metadata set which describes all data covered by the EU Directive and the respective specifications. This minimum metadata set describes the most important data elements, a technical description of the data elements and contains all necessary information for the metadata definition necessary to fulfil the duties of the national SPAs.

35 Information collected from European ITS Platform (EU EIP)



The different parts of the metadata catalogue will be explained further.

There is room for more standardization in the current specifications of required formats in the National Access Points (2/2)

Metadata catalogue - explained

Publication
A publication is an abstract information element that covers the (recurring) data set(s) of a distinct content provided in a specific data format based on a specific communication method. So a publication is the combination of a data set and the way the data is published (made accessible). The same data set (e.g. static parking information for truck drivers) can be provided in different ways e.g. as downloadable zip file or as XML using a SOAP web service. These are two publications based on one data set.

Metadata set
Metadata contain information about a publication facilitating discovery services. Metadata set is the collection of all metadata elements.

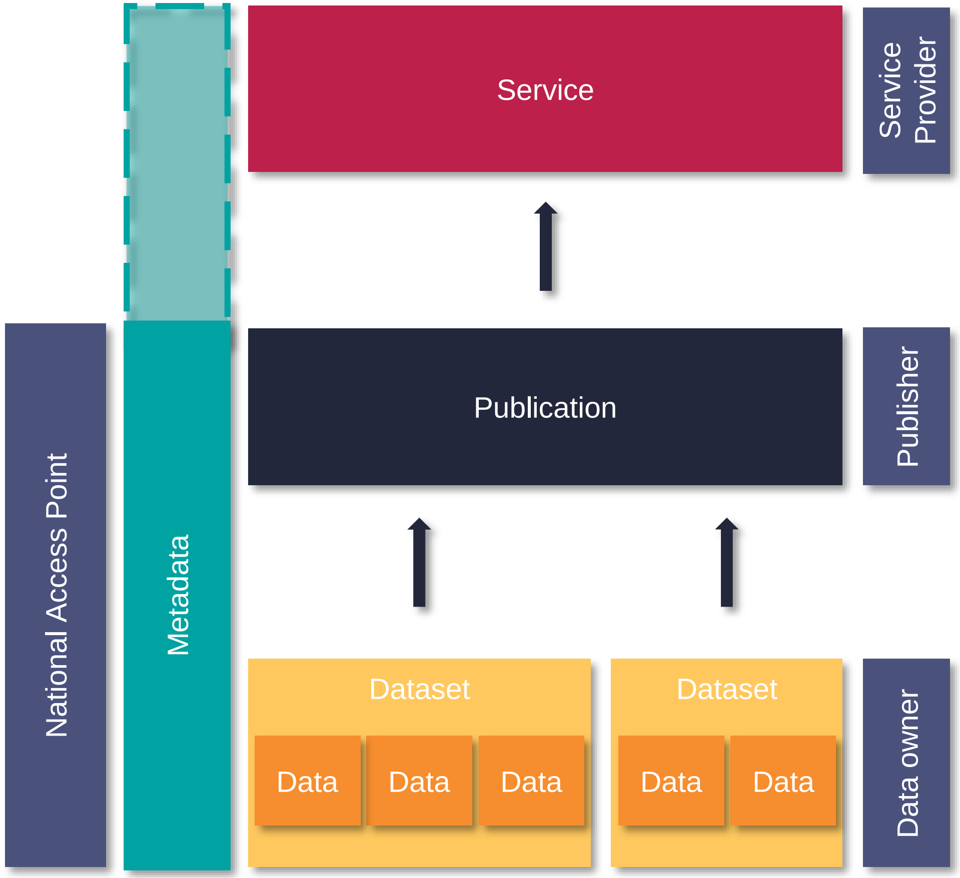
Data set
A data set contains the road and traffic data which is provided by the data owner.

Publisher
A Publisher is the entity (company, authority or person) who publishes a dataset. It holds up the data access and defines data routines.

Contact Point
A Contact Point is the entity (company, authority or person) who registered the dataset at the SPA and is liable for the correctness of the metadata. In most cases this will be the data owner.

Data Owner
A Data owner is the entity (company or authority) which owns or produces data. It is liable for processing, aggregation, quantity and quality of the data.

35 Information collected from European ITS Platform (EU EIP)



Use cases from the authorities perspective

Road authorities in European countries have different structures, but in one way or another they are an administrative body working for safe, environmental friendly, efficient and universal designed transport systems in their respective country. Connected vehicles and mobility services will provide a vast amount of opportunities for road authorities to significantly improve their services to fulfill their mission. In the following section we will present a sample of use cases to showcase the great potential automotive data sharing has on improving the operations of road authorities. Some of the use cases will also support readiness for automation.

European NRAs are realizing use cases within road safety, traffic efficiency and sustainability

Throughout the interviews, road authorities have expressed enthusiasm about the possibilities increased use of vehicle generated data have to improve their operations and services. There are, however, differences in the maturity level of authorities when it comes to exploring these benefits. We experience that those who are leading the adoption of vehicle generated data has an agile approach to their projects, and give themselves the room for trial and error. This is a field with extensive research and collaboration, but authorities are still in the exploration phase, and there is not yet consensus of what use cases will provide the greatest value. Hence, knowledge sharing across boarders and pan-European collaborations will enable more rapid adoption of successful use cases.

	Increased road safety	**Efficient traffic**	**Increased sustainability**
Data sources	• Information shared by users: broken down vehicle, obstacles, accidents, bad weather • Information supplied by vehicles: lights, warnings, ESP – V2V communication • Special vehicles (dynamic events): long or wide, emergency vehicles	• Data for traffic efficiency: optimizing the use of infrastructure to reduce congestion • Real-time traffic light information • Information of works in execution in real-time • Special vehicles (dynamic events): long or wide, emergency vehicles	• Information on location of interest, e.g. EV charging points • Data for traffic efficiency: optimizing the use of infrastructure to reduce congestion • Virtual message panel: possible to use to report activation of pollution protocols • Data for condition of roads and assets
Benefits	Data sharing on mentioned events increases road safety by informing road users about accidents, unexpected conditions and other obstacles or hazards, as well as providing safer driving conditions for special vehicles.	Increased traffic efficiency will be driven by road users accessing data enabling smart navigation systems to optimize routes, prioritizing emergency vehicles, and avoiding congested areas when possible.	By optimization route planning for EV-drivers usage of EVs can increase, informing drivers on pollution and restrict driving when high density, and optimize maintenance to save resources, one can promote sustainability in driving and road authorities operations.

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They are also looking to provide better information, increase internal operations and improve the infrastructure

Better information on road conditions

Data sources

- Data for weather conditions: vehicle generated data like windshield wiper movement, fog lights, temperature
- Data for slippery roads: vehicle generated data like location, time, temperature, traction control, ABS/wheelspin or speed
- Data for unexpected traffic condition

Benefits

Road conditions are very dynamic, by providing real time data on road conditions authorities can offer better services for road users enabling them to take better actions based on the current conditions in an area about to enter.

Better information on accidents

Data sources

- Information shared by user: broken down vehicle, obstacle, accident, bad weather
- Data for unexpected traffic condition/accident: vehicle generated data like steering and braking intervention, airbag, camera images, speed

Benefits

Increased information of accidents firstly allows for instant notifications to authorities and/or emergency services for them to efficiently act with the best possible response. Secondly, it allows to alert road users so they are prepared to adjust speed or route.

Increased efficiency road authority operations

Data sources

- Data for condition of assets: vehicle generated data used to improve road quality or road side maintenance
- Data for slippery roads: vehicle generated data like location, time, temperature, traction control, ABS/wheelspin or speed
- Data for weather conditions
- Data for unexpected events

Benefits

The operations of road authorities can be significantly improved by utilizing automotive data sharing. Maintenance can be done based on needs and not calendar, salting of roads can be done more efficiently based on needs, and it enables more dynamic speed limits for example based on conditions.

Improved infrastructure

Data sources

- Information on location of interest, e.g. EV-charging points
- Virtual message panel: possible use to report activation of pollution protocols
- Data for condition of assets: vehicle generated data used to improve infrastructure

Benefits

Based on data from vehicles road authorities can expand the infrastructure provided. Either own services, or services provided by third parties. EV-charging points can be expanded based on high demand and usage in an area, new and/or more dynamic signage to inform drivers will also be possible.

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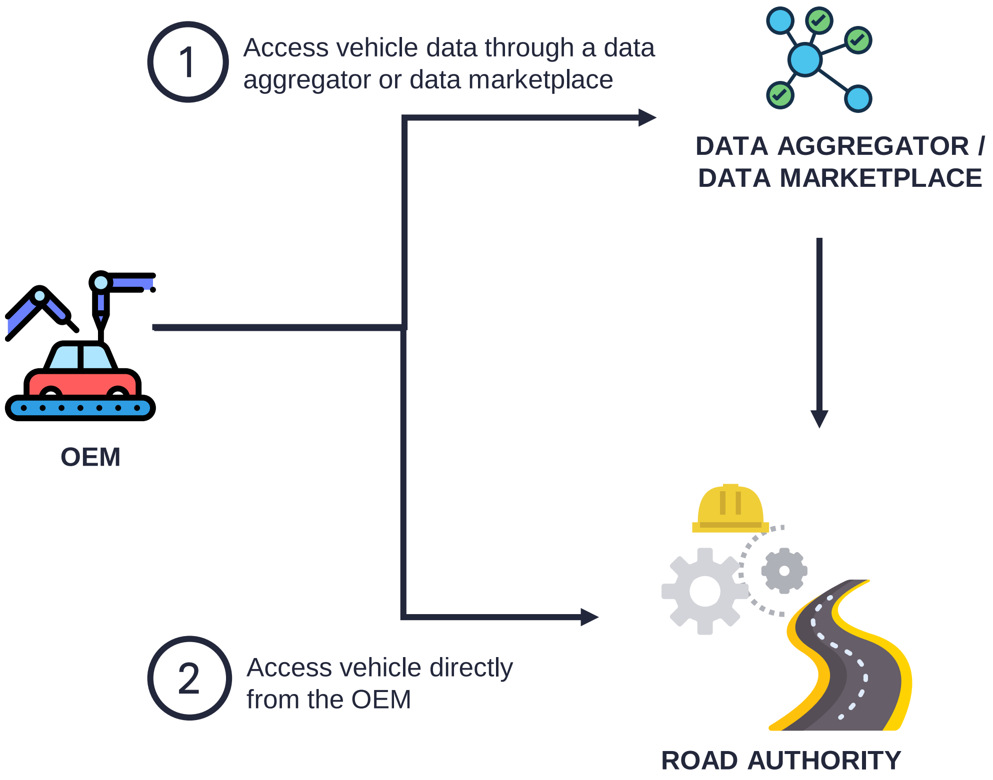
Cost of data acquisition

From a NRA perspective, obtaining vehicle generated data is unchartered territory. There are ongoing initiatives in several countries, but we are yet to get a clear answer when it comes to pricing. This might be because the price of the data depends on the use case.

The incurred cost for a road authority utilizing vehicle generated data depends on how they access and source the data (1/2)



For a road authority there are two main ways to access vehicle generated data, either directly purchase the data from OEMs or through a data aggregator or data marketplace. The two approaches have their pros and cons.

1. Access through a data aggregator or data marketplace

There are several technology providers positioning themselves as a data aggregator or data marketplace where road authorities and other stakeholder can purchase vehicle data.

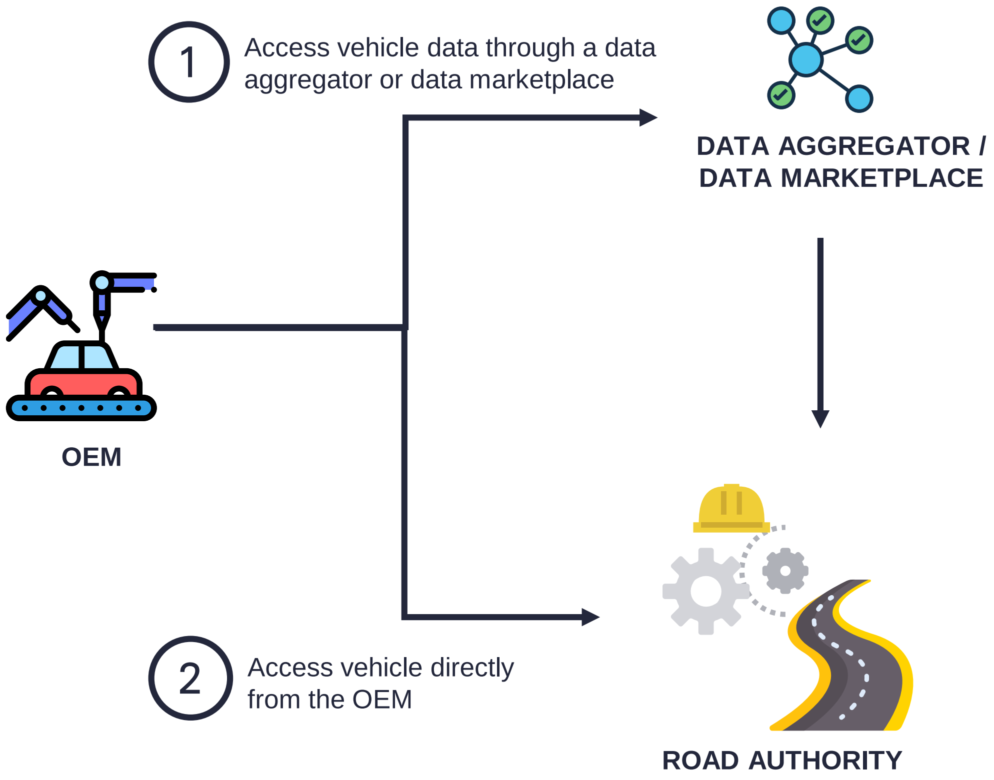
The benefit of this approach is:

- Less administrative work with fewer contracts
- Data will be cleaned and structured in the same format
- Data will be contextualized
- Can deliver solutions for insight and not raw data

The challenges of this approach are:

- More expensive
- Price dependent on use case

The incurred cost for a road authority utilizing vehicle generated data depends on how they access and source the data (2/2)



2. Access direct from the OEMs
Many OEMs provide the opportunity to access their data through their APIs or ability to purchase data directly from the OEM.

The benefit of this approach is:
- Price – cheaper with no aggregator

The challenges are:
- More administrative work with more contracts
- Less complete data as some OEMs would not allow direct data sharing
- Access to "raw data"
- Not contextualized

Alternative: A Neutral Server

The concept of a Neutral Server is a heavily debated subject among OEMs. The data acquisition would be similar to the other two approaches, but since neither the OEM nor the data aggregator knows the purpose of the use, price differentiated on use case would be more difficult.

Benefit of this approach is:
- Price – cheaper with no price differentiation
- Cross-brand harmonized data

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There are both permanent and temporarily costs related to the establishment and operation of a connected vehicle platform

TEMPORARILY COSTS

Human resources & Competence
The establishment of technological architecture to utilize vehicle generated data requires competence on fields like information and technology architecture, data engineering, data scientist, and analysts. In addition to the new competence, the development of a platform will be time consuming. These can be covered by either:
Consultancy services is one way to handle the competence and heavy resource requirements in the early phases.
Re-skilling or new hires is an alternative approach and will be temporary as the organization over time will adjust to the new way of operating by reallocation resources.

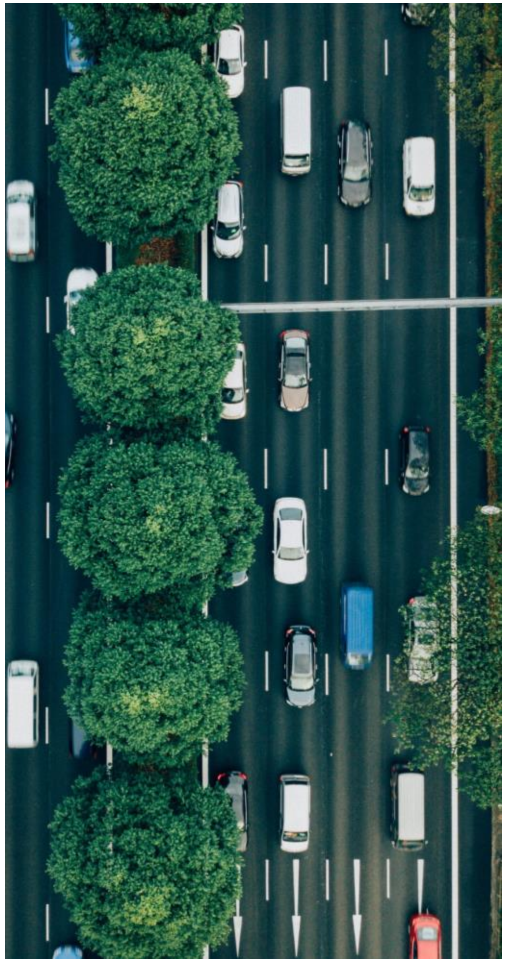
PERMANENT COSTS

Accessing vehicle data will drive cost. Dependent on how one access the data these costs can differ. Many technology providers position themselves to deliver vehicle data, and all have different business models. The Netherlands having 13 contracts on accessing vehicle data confirms this.

In addition to different prices from different providers, the same provider also might have complex pricing. As the CEO of one data provider confirms in an interview with BCG the price of the same data can vary depending on the value of the use case the data is supposed to support

Cloud consumption will drive costs, both the hosting and the transactions of data. A national road authority utilizing car data will, independent of the way chosen to accessing data, have costs related to storage and transaction of data. Either it will increase current costs related to data costs or it will introduce a new element of costs for the authority.

Vehicles generates millions of data points every second, so as a consumer of the data national road authorities should have a strategy for what, how and for how to store data, and a technological architecture to cope with this challenge.



Chapter 5:

Technology Providers are Entering the Automotive Industry

Chapter 5: Technology companies are entering the automotive industry

Technology companies are entering the automotive market with rapid pace as digital adoption and data sharing in the industry increases. Technology companies with different capabilities are interested in taking a market share in this market, everything from big techs to small start ups with narrow specialties are competing to strengthen their position in the eyes of customers, authorities and OEMs.

1. Key takeaways from qualitative studies

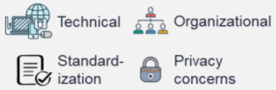
We will present the key takeaways from the qualitative research we have done by interviewing stakeholders in the automotive industry.

2. A sample of different approaches and spotlights on some technology providers

We will provide an overview of a sample of different technology companies in the industry, and present the different approaches they have taken. Further, we will give some more detailed information about a few of the technology companies.

3. The technology giants are taking a seat at the table

We will provide a brief introduction to the Big Techs approach and services in the automotive industry.



4. Barriers to data sharing in the automotive industry

To wrap it up, we will present a few, but highly important barriers to data sharing in the industry.

Technology players has a role to play in the automotive data ecosystem

Technology providers are increasing their footprint in the industry

Technology companies are becoming an increasingly important player in the automotive data ecosystem. Some of the major technology companies already have extensive map and location based services, and see automotive data as a natural expansion of their services. Among the technology players in this sphere we find companies with a background from mapping and navigation such as Waze, Here Technologies and TomTom.

Unlike the traditional players in the automotive industry, these companies have extensive in-house knowledge and experience in managing and utilizing massive amounts of data.

While navigation and mapping companies are increasingly becoming data aggregators, other have specialized in becoming one-stop-shop data marketplaces for vehicle generated data. In this space we find players like Otonomo and High Mobility. These companies specialize in making agreements with automotive OEMs and sell the aggregated data through their marketplace.

Other companies specialize in more narrow fields such as dongles (GeoTab) or Traffic Light information (TTS), with initiatives around the US and in some European cities – like Ingolstadt, where TTS and Audi are collaborating in a V2I project to connect vehicles with traffic lights.

The large technology companies are also positioning themselves in the automotive industry with self driving car projects, automotive software and infotainment services.

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A sample of different approaches and spotlight on some technology providers

As many technology companies are competing for the driver’s seat in the market of connected car data, we find that there are several roads that lead to their destination. In the following section we will show a sample of the different approaches to data acquisition, data transformation, contextualization and sharing, in addition to added services before we place the spotlight on a couple of actors within the industry.

Technology players are taking different approaches to data acquisition, data transformation, contextualization and value adding services

	TomTom	waze	NIRA Dynamics	here	HM High-Mobility	Caruso dataplace	otonomo	GEOTAB management by measurement
Data acquisition	Sat-nav devices, in-vehicle software, and cloud-to-cloud OEM data	Connected devices and users of their apps	Software installed in vehicles	In-vehicle software and V2V OEM data	Cloud-to-cloud OEM data	Cloud-to-cloud OEM data	Cloud-to-cloud OEM data	Data acquisition through dongles (OBD II)
Data transformation, contextualization and sharing	Contextual and cleaned data. Open sharing of sharing SRTI	Contextual and cleaned data.	Contextual and cleaned data.	Contextual and cleaned data. Open sharing of sharing SRTI	Contextual and cleaned data.	Contextual and cleaned data.	Contextual and cleaned data.	Contextual and cleaned data.
Value added services	Harmonized multi-brand in-vehicle data of different vehicle manufacturers, and maps	Traffic services	Harmonized multi-brand in-vehicle data of different vehicle manufacturers in one location	Harmonized multi-brand in-vehicle data of different vehicle manufacturer, and maps	Harmonized multi-brand in-vehicle data of different vehicle manufacturers in one location	Harmonized multi-brand in-vehicle data of different vehicle manufacturers in one location	Harmonized multi-brand in-vehicle data of different vehicle manufacturers in one location	Harmonized cross-brand data, even from "legacy" cars through OBD II port.

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Spotlight: HERE Technologies' Open Location Platform

HERE's Open Location Platform

Real-time sensor data from vehicles across brands are already collected by HERE, a map services company. Their Open Location Platform absorbs this information, which can be as simple as location, heading, and speed. In addition, feedback from use of hazard lights and fog lights, emergency brakes or electronic stability control, even from cameras built into the cars, can all be blended into the Open Location Platform's database.

The platform offers map-matching solutions to convert raw GPS traces to a coherent network representation, and data is anonymized and aggregated. Through the platform HERE are not only providing access to a repository of location data, but they have also included traffic and weather data. The Open Location Platform helps actors in the mobility ecosystem access merged data from a variety of sources to develop new products (such as a navigation map for cyclists) and monetize their location-based data (such as GPS traces and pothole information).

Photo: Here Technologies

Case study

Enhancing traffic management measures with BMW

HERE is collaborating with, among others, BMW on SOCRATES 2.0, a program that promotes continuous deployment of European-wide traffic management measures. Road authorities, service providers and car manufacturers will participate in four pilot projects in Amsterdam, Copenhagen, Munich and Antwerp, which aims to evaluate the feasibility and usefulness of implementing largescale and interactive traffic management solutions. The following four use cases will be deployed:

1. Smart routing
2. Actual speed and lane advices
3. Local information and hazardous warnings
4. Improved roadside traffic management measures

Results will be deployed quickly and replicated throughout Europe.

Spotlight: Otonomo's Automotive Data Services Platform

Otonomo
The Otonomo Automotive Data Services Platform fuels a network of 15 OEMs and more than 100 service providers. The neutral platform securely ingests more than 2 billion data points per day from over 18 million global connected vehicles, then reshapes and enriches it to accelerate time to market for new services that delight drivers[36]. The Otonomo Automotive Data Services Platform uses patented technology to ingest, secure, cleanse, normalize, aggregate, and enrich car data from multiple sources. It delivers application-ready datasets and insights, and eliminates a significant amount of the development work needed to launch apps and services based on connected car data[37]. The Otonomo Platform provides secure data management and gives drivers granular controls over how their personal automotive data is shared. Patented technology performs anonymization for use cases requiring anonymous or aggregated data. Many mobility services can't operate well without data from multiple automotive manufacturers (OEMs). Yet individual OEMs lack incentives to consolidate each others' data. As a neutral third party, Otonomo aligns OEMs and the multitude of valuable apps and services that use car data. Third-party apps and services gain easy data access, while OEMs maintain control over which services can access their data.

Data architecture for automotive applications – Otonomo

"Mercedes-Benz and Otonomo share the same vision and values when it comes to delighting customers while protecting their data. Together with Daimler, our solution is bringing the neutral server concept to life."
- Ben Volkow, CEO, Otonomo

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Spotlight: TomTom's location based platform with HD-maps

TomTom's location based platform

TomTom is one of the leading location technology specialists, shaping mobility with highly accurate maps, navigation software, real-time traffic information and services.

TomTom's services are utilized by cities, governments and planning departments to analyze and improve traffic and travel. Their platform offers tailored solutions with scalability, and they are providing historical and real-time traffic data as a service, standalone or combined with other datasets and infrastructure networks.

TomTom is engaged in the work of Data Task Force, and delivering services related to the sharing of safety related traffic information. In addition to services related to road safety, TomTom provides services on traffic modeling, transport planning and real-time traffic monitoring with in the scope of their road traffic management services[38].

TomTom has also done extensive work on the field of HD-maps, which is one of the most important enablers for autonomous driving being adopted more widely. Highly accurate and efficient maps are delivered from TomTom in the service called RoadCheck. The service make OEMs able to prohibit vehicles from activating driving automation functions in potential dangerous areas, and allow it in safer area[39]. The HD-maps are used by multiple global OEMs for development in their vehicles, and TomTom is testing the software in their own test vehicle.

Photos: TomTom

Case study – TomTom autonomous driving

TomTom's autonomous test vehicle hits the road

TomTom engineered their own self-driving test vehicle to continually test and improve their software and technologies, including the HD-map and car-to-cloud-to-car map update services[40].

The car sees through LiDARs, radars and stereo cameras, and combines this with a highly intelligent, software-powered brain to enable the car to see far beyond these sensors and take smarter decisions more efficiently.

After every drive, the TomTom car will send data and insights to the TomTom's autonomous driving development team. They will test the vehicle in the streets of Berlin, navigating thoroughfares and high streets, and sharing space with motorists, cyclists, and pedestrians giving a more nuanced understanding than highspeed and more predictable highway driving typically does.

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Spotlight: Geotab's dongles enables connectivity

Geotab are utilizing dongles to increase connectivity

Geotab is working with advancing security, connecting commercial vehicle to the internet and providing web-based analytics to enable better management of fleets. They provides an open platform and marketplace that allows companies to automate operations by integrating vehicle data with their other assets[41].

Geotab function as an IoT-hub, and are leveraging data analytics and machine learning to help their customers improve productivity, optimize fleets through the reduction of fuel consumption, enhance driver safety, and achieve regulatory compliance.

They are utilizing dongles for data acquisition, and use the internal networks in the vehicle to capture the data. By doing this they are able to collect accurate and reliable data on location, speed, trip distance and time, engine idling and more. This provides useful information for their customers about vehicle health and status and collision detection and notification[42]. One of the benefits by utilizing dongles is that Geotab are able to offer connected vehicle services also for customers with older vehicles. There is still a significant amount of cars without embedded telematics, and hence a market potential in retro-fitting older cars with modern technology. Or, connect vehicles across brands by implementing a common external device.

Geotab have agreements with several global OEMs: Ford, GM, International, John Deere, Mack, Volvo and Mercedes-Benz Connectivity Services.

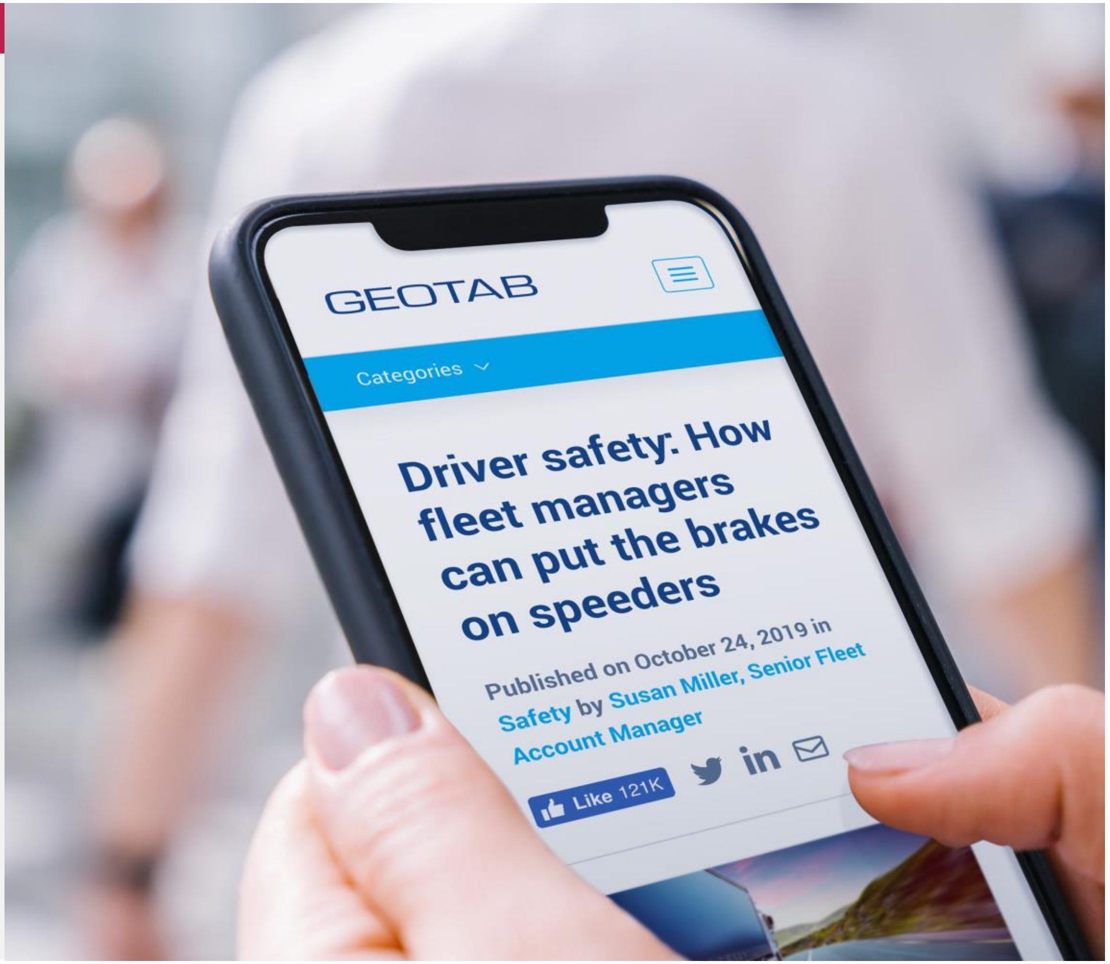

Photo: GeoTab

The technology giants are taking a seat at the table

The technology giants' bread and butter is data. They are always looking to expand their business into new verticals, and the automotive industry is a compelling vertical with the promise of big data and consumer exposure. All the usual suspects are taking a position within the automotive industry, with a focus on data, cloud consumption, artificial intelligence and software development.

Technology giants are taking a seat at the table

How are the technology giants entering the industry?

Apple wants to become a relevant leading player not only with their CarPlay system, but also with software related to autonomous driving

Google offers Android Auto, a smart driving companion bringing information such as destinations, appointments, and weather conditions to the driver. Google's sister company Waymo is at the forefront of the development of self-driving technologies

Microsoft offers intelligent services in the car, including virtual assistants, business applications, office services and productivity tools with their Connected Vehicle Platform

Amazon brings their voice-controlled, intelligent personal assistant Alexa into cars, thereby creating a seamless transition from the home to the car

Alibaba is pushing for the car and the Internet of Things by developing their own operating system, AliOS, which includes touchscreens, GPS maps and other smartphone-like functionalities

Tencent is the last entrant into the crowded autonomous driving space. It was a surprise when the news emerged in November 2017 that the owner of the "Chinese Facebook" is developing their own autonomous driving system

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Barriers to data sharing in the automotive industry

Even though the value proposition of vehicle generated data is great, there are a number of barriers to overcome. In the following page, we will outline some barriers highlighted by the interviewees throughout our interviews.

Barriers to data sharing in the automotive industry are found within the space of technology, standardization, organization and data privacy

Technical

The technological maturity of OEMs are varying, and there is a wide spread when it comes to actual connectivity and frequency on data uploads. Also, there is varying maturity when it comes to data quality, data transformation and technological platform. As more and more cars are shipped with embedded connectivity, data management will be important

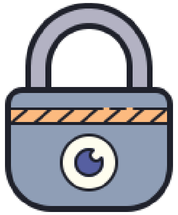
Standardization

There are already a number of agreed upon standards, but there are still lots to be done in terms of standardization to make data harmonized across brands, countries, products and companies. Governments have an important role to play in establishing standards in close cooperation with private companies using the standards

Organizational

Both OEMs and NRAs have a shifting demand for skills and competencies when it comes to utilizing vehicle generated data. There are also some barriers when it comes to data-driven culture and readiness for change in the organizations. This is a common denominator in a number of businesses dealing with digital transformation

Privacy concerns



OEMs in the European market are very careful when it comes to data privacy. Since data privacy is at the utmost importance for the OEMs, this can be seen as a barrier to accessing vehicle generated data. Although, it is possible to work around the data privacy regulations by only using anonymized data on an aggregated level

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Chapter 6:

KPMG Recommendations

The recommendations for the road ahead is given within eight dimensions

Selecting approach for a connected vehicle platform can be difficult for NRAs. The impact of three approaches is presented in the following pages. The approaches are outlined within the following eight dimensions:

Strategic

1. **Strategic ambition** – the overall approach, which will determine the requirements for organizational and technical capabilities, and investments.

Organizational capability

2. **Organizational resources** – the capacity needed to develop and operate the platform
3. **Competency requirements** – competency needed to develop and operate the platform
4. **Partnership and ecosystem** – collaboration with third parties

Technical capability

5. **Technology platform** – degree of open innovation and open source
6. **Data sources and transformation** – number of data sources and how the data is transformed
7. **Data sharing** – degree of data sharing and number of datasets shared

Investment

8. **Investments** – capital investments needed to develop and operate the platform

The scenarios are based on information from our interviews and our understanding of the complexity of building a connected vehicle platform, both from a technological perspective and a organizational perspective

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Scenario 1: Regulatory compliant

In this scenario, the NRA will only implement the functionality necessary to be regulatory compliant. The NRA will be a follower, not a leader – and learn from the leading NRAs. It will require limited resources and the scope of competency will be low. There will be a need to partner up to cover some of the competency gaps, as a connected vehicle platform requires some competencies that normally don’t sit within road authorities, and is not strategically important enough to hire. The technological platform can be a closed system, with limited open innovation. Data gathering and transformation is done internally, while the amount of data that is shared will stay at the minimum to meet the regulatory requirements. Investments in this scenario will be fairly low.

Scenario 1: Regulatory compliant

Group	Dimension	Specter of selected approach	Description of implications of selected approach
	Strategic ambition	Follower — Innovator	A regulatory compliant approach implies implementing the minimum requirements to stay compliant. The organizational and technological capabilities will be limited to a minimum, in line with the investments.
Organizational capability	Organizational resources	Limited — Extensive	Limited need for resource capacity in the organization as the approach will focus on the core resources to enable data sharing. Extended capacity can be sourced from external suppliers.
Organizational capability	Competency requirements	Limited — Extensive	Competency requirements focusing on regulatory aspects, data platform architecture and sourcing competence in order to acquire additional resources.
Organizational capability	Partnerships and ecosystem	Internal — Integrated	External resources will be brought in to supplement gaps in the internal organization, to satisfy regulatory requirements and safety provision.
Technical capability	Technology platform	Closed system — Open innovation	The technology platform will primarily be based on a closed system where some additional datasets can be acquired periodically.
Technical capability	Data sources & transformation	Internal — Externally augmented	Data transformation with limited external mix, in order to satisfy regulatory data points and focusing on complying with the delegated acts under the ITS directive.
Technical capability	Data sharing	Regulatory required — Value added services	Sharing of data will be done in accordance with regulatory mandate and with use-cases targeting safety.
	Investments	Low — High	Minimize investments required by solely developing the minimum set of organizational and technological capacity. Source additional capacity and data from third party to close any regulatory gaps.

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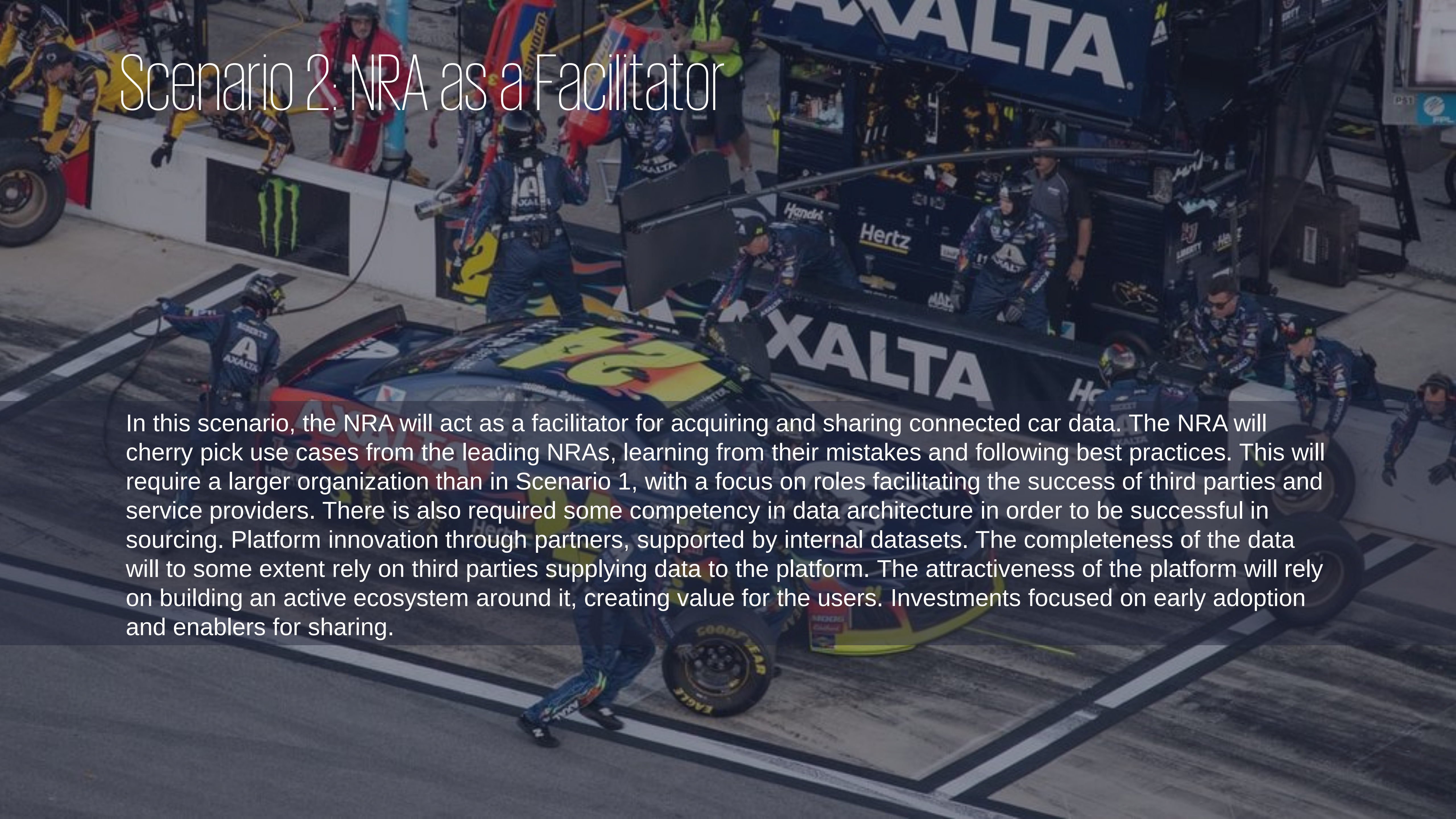
Scenario 2: NRA as a Facilitator



In this scenario, the NRA will act as a facilitator for acquiring and sharing connected car data. The NRA will cherry pick use cases from the leading NRAs, learning from their mistakes and following best practices. This will require a larger organization than in Scenario 1, with a focus on roles facilitating the success of third parties and service providers. There is also required some competency in data architecture in order to be successful in sourcing. Platform innovation through partners, supported by internal datasets. The completeness of the data will to some extent rely on third parties supplying data to the platform. The attractiveness of the platform will rely on building an active ecosystem around it, creating value for the users. Investments focused on early adoption and enablers for sharing.

Scenario 2: NRA as a facilitator

	Dimension	Specter of selected approach		Description of implications of selected approach
	Strategic ambition	Follower	Innovator	A facilitator of open innovation on automotive data through collaboration with third party partners and the ecosystem. Requires some technological and organizational capabilities to enable value adding services
Organizational capability	Organizational resources	Limited	Extensive	Organizational resource capacity is kept at a minimum level, in order to play the role as a facilitator, leveraging the external ecosystem and other market actors in terms of volume.
Organizational capability	Competency requirements	Limited	Extensive	Competency requirements based on a limited number of internal subject matter expertise related to data platform architecture and facilitators of third party/ecosystem collaboration.
Organizational capability	Partnerships and ecosystem	Internal	Integrated	As a facilitator, the NRA must leverage external partnerships and ecosystem to delivery services. This means a clear division of roles, where the external parties are developed into alliances.
Technical capability	Technology platform	Closed system	Open innovation	The platform will support the ecosystem with internal data, but the responsibility for further innovation will be motivated by the corresponding commercial contracts, enablement and alliances.
Technical capability	Data sources & transformation	Internal	Externally augmented	Internal and external data is mixed in order to provide better opportunities for data transformation and value add. The degree of augmentation will increase as more partners become active
Technical capability	Data sharing	Regulatory required	Value added services	Ownership of the transformed data must regulated by clear agreements on “commercial use”. The value of the data being transformed will be dependent on a set of commercially viable services. Opportunities to scale with reusable data-assets.
	Investments	Low	High	The goal is to try and limit the NRAs own investment by facilitating market forces, alliances and partnerships, to do more of the “heavy lifting” in capability development. Investments focused on early adoption and enablers for sharing.

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Scenario 3: NRA as a service provider

In this scenario, the NRA will act as a service provider. This implies an elaborate approach from the NRA, meaning that they are innovative and leading in their strategy, and review this frequently. This will have implications for the organizational and technical requirements in the organization. The organizational requirements will be extensive, in terms of resources this approach requires an organization with big capacity and a broad skillset of competence. In addition, it requires an active role in creating and exploring partnerships and ecosystems to successfully extend services. Through an open innovation platform the NRA encourage third party developers and external partners to continuously improve their platform. Succeeding in this approach also requires extensive technological capabilities in collecting and transforming data from “raw” data to useful insights for third parties, in addition to enable value adding services through data sharing. A holistic approach will require high initial investments, but can potentially enable new revenue streams or cost reduction for NRAs.

Scenario 3: NRA as a service provider

Group	Dimension	Specter of selected approach		Description of implications of selected approach
	Strategic ambition	Follower	Innovator	A proactive service provider that enables a wide set of use cases enabled by automotive data sharing. Requires the NRA to actively develop capabilities in line with technological advancements and utilize ecosystem partnerships
Organizational capability	Organizational resources	Limited	Extensive	To obtain a leadership position it will require extensive resources that the organization either will have to source in or build internally.
Organizational capability	Competency requirements	Limited	Extensive	To bridge the technology gap, a broad skillset will be required. Including, but not limited to, software engineering, data science, data engineering, digital architecture and BI. In addition partner & ecosystem development and change management is required
Organizational capability	Partnerships and ecosystem	Internal	Integrated	Partners are closely integrated as part of the service delivery. Thriving ecosystem around the platform adding value to the existing services
Technical capability	Technology platform	Closed system	Open innovation	Open technology platform to promote open innovation through third party developers and external partnerships with service providers
Technical capability	Data sources & transformation	Internal	Externally augmented	Collecting data, transforming its value by augmenting/ contextualizing them with external data sources. External data can be provided by open data sources and/or sourced through partnership collaboration and/or data aggregators
Technical capability	Data sharing	Regulatory required	Value added services	New value adding services are enabled by the data platform taking advantage of the enriched contextualized data from both internal sources and from external collaborators
	Investments	Low	High	To sustain an innovator approach will require significant investments in order to develop the required technological, organizational capabilities along with developing partnerships and ecosystems

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Recommendations have been given for three different scenarios

Scenario 1: Regulatory compliant

- The NRA will only implement the functionality necessary to be regulatory compliant.
- It will require limited resources and the scope of competency will be low. There will be a need to partner up to cover some of the competency gaps.
- The technological platform can be a closed system, with limited open innovation. Data gathering and transformation is done internally, while the amount of data that is shared will stay at the minimum to meet the regulatory requirements.
- Investments in this scenario will be fairly low.

Recommended approach for Statens Vegvesen

Scenario 2: NRA as a facilitator

- In this scenario, the NRA will act as a facilitator for acquiring and sharing connected car data.
- This will require a larger organization than in Scenario 1, with a focus on roles facilitating the success of third parties and service providers, and it requires some competency in data architecture in order to be successful in sourcing.
- Platform innovation through partners, supported by internal datasets. The completeness of the data will to some extent rely on third parties supplying data to the platform. The attractiveness of the platform will rely on building an active ecosystem.
- Investments focused on early adoption, enablers for sharing and data utilization.

Scenario 3: NRA as a service provider

- In this scenario, the NRA will act as a service provider, where NRAs have an innovative and leading strategy.
- The organizational requirements will be extensive, in terms of resources this approach requires an organization with big capacity and a broad skillset of competence, and an active role in creating and exploring partnerships and ecosystems.
- Through an open innovation platform the NRA encourage third party developers and external partners to continuously improve their platform. This approach also requires extensive technological capabilities in collecting and transforming data from “raw” data to useful insights for third parties, in addition to enable value adding services through data sharing.
- A holistic approach will require high initial investments, but can potentially enable new revenue streams or cost reduction.

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